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# COMPARISON OF BOARS, BARROWS AND GILTS AS MEAT PRODUCING ANIMALS

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "Comparison of Boars, Barrows and Gilts as Meat Producing Animals" submitted by Jorge Alfredo Newell, B.Sc., Eng. Zoo., in partial fulfilment of the requirements for the degree of Doctor of Philosophy, in Animal Nutrition.

# ABSTRACT

Studies were undertaken to compare performance of boars, barrows and gilts. A preliminary study with laboratory rats showed that this species cannot be used as a predictor of comparative sex performance of swine. The objectives of the first experiment were to evaluate the effects of sex and dietary protein level on the performance, carcass composition and fat composition of boars, barrows and gilts fed either 18% protein throughout or a 16% protein growing diet and a 13% protein finishing diet. During the growing period boars ate less ($P < 0.05$) than barrows. Higher dietary protein improved ($P < 0.01$) gain. A significant interaction existed for gain between sex and protein with boars responding more than barrows or gilts to high dietary protein levels. Feed conversion was influenced ($P < 0.05$) by sex and protein level; boars being superior to barrows or gilts and pigs fed the higher protein diet superior to those fed the lower protein diets. Both barrows and gilts dressed higher ($P < 0.01$) than boars. Boars had a grade index of 102.6 and gilts 101.4, both of which were higher ($P < 0.01$) than barrows with 97.9. Other carcass measurements generally ranked the sexes in order of superiority as boars, gilts and barrows. Boar carcasses had more muscle and less fat ($P < 0.01$) than barrows with gilts being intermediate. Dietary protein level did not significantly influence carcass composition. No significant differences between sexes were found in six muscles which were analyzed for protein, fat and ash. Fatty acid analyses of backfat showed no significant differences except in linoleic and linolenic acids, for which boars and gilts had higher percentages than barrows. Although no statistical differences were found in metabolism studies conducted at 15 and 50 kg liveweight, barrows tended to digest more nitrogen but to retain less than boars or gilts. The three sexes were found to be similar for energy digestibility and for metabolizable energy.

A second experiment was conducted to assess the effects of either diethylstilbestrol (DES) implantation or late castration (at 70 kg liveweight) on the performance, carcass composition and olfactory evaluation of boars. Barrows ate more ($P < 0.05$) and required more feed per kg gain than implanted, castrated or intact boars or gilts. No statistical differences between treatments occurred in rate of gain for the entire experiment. Barrows had thicker ($P < 0.05$) backfat and lower ($P < 0.05$) grade index than any of the other treatments. Late castrated boars showed a general trend to revert to the performance characteristics of barrows but were still superior to barrows at market weight. No significant differences between treatments were found for dry matter, protein, fat or ash content of the longissimus dorsi muscle. Biopsy fat samples taken from boars showed a decrease in taint, evaluated chemically or by a sensory panel, after either implantation or late castration. Correlation and regression analyses suggested little change in taint in the intact boars after 70 kg. Biopsy fat samples taken at 70 kg should give a good prediction of the degree of taint to be expected later in a carcass, if a boar is not treated to reduce taint. No residual DES was found in muscle tissue of implanted boars.

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# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# INTRODUCTION

Boar carcasses are rejected by markets in some countries, including Canada, because of the possibility of odor in the meat or fat of entire male animals, while in other countries boar meat is an accepted part of the diet. In Canada, boars cannot be marketed through federally inspected packing plants, although ridglings (cryptorchids) are accepted in regular market channels. Such carcasses are separated by being identified on the rail and subjected to an aroma test to determine their suitability for regular retail outlets.

Some aspects of meat production from boars have been discussed in a symposium on meat production from entire male animals (Rhodes, 1969). Most studies have indicated that boars have a superior rate of gain, improved feed conversion and leaner carcasses than barrows with gilts usually being intermediate in these criteria. Level of dietary protein may be a factor influencing comparative results between sexes.

The objectives of two experiments with a total of 108 pigs were: (1) To evaluate the effects of sex and dietary protein level on the performance, carcass composition and fat composition of boars, barrows and gilts fed diets containing either 18% protein throughout or 16% protein up to 50 kg liveweight and 13% protein from 50 kg to market weight of 90 kg and (2) To compare performance and carcass characteristics including sexual odor of boars castrated at 70 kg liveweight, boars treated with diethylstilbestrol (DES) at 70 kg liveweight, intact boars, barrows and gilts. Energy and nitrogen metabolism studies comparing boars, barrows and gilts were also conducted. A preliminary experiment was carried out with laboratory rats. The experiments reported in this thesis were conducted between April 1970 and August 1972.

# REVIEW OF LITERATURE

Pigs are born in a sex ratio which, as yet, is beyond our control. As far as pig production is concerned, a potential decision involves the choice between intact boars and castrate male (barrow) carcasses. However, the risk of occurrence of taint in the fat of boar carcasses has prevented exploitation of this otherwise desirable source of pork.

## Effect of sex on live performance

Most of the studies dealing with sexes compare the performance of the female (gilt) and the barrow. Numerous researchers have reported that barrows grow faster than gilts (Bruner and Swiger, 1968; Crampton and Ashton, 1945; Jensen et al., 1955) and that barrows reach market weights at an earlier age than gilts (Bruner et al., 1958). However, Lucas and Calder (1956) found no overall difference in average daily gain (ADG) between sexes. Systems of feeding could be a factor influencing comparative performance. Bowland (1966) reported that barrows fed ad libitum grew faster than gilts and also observed that barrows had a higher average daily feed intake (ADF) during the finishing period. Clawson et al. (1962) and Hale et al. (1968) also observed that barrows ate more and were less efficient in feed conversion (FC) than gilts. In other studies comparing barrows and gilts, no differences were found with respect to FC (Robinson and Lewis, 1964; Robinson et al., 1964; Young et al., 1968). Plank and Berg (1963) observed that on restricted feeding, gilts were superior to barrows in FC but that when a system of liberal feeding was used this advantage disappeared.

The reported improved performance of the intact male over the castrate has increased interest in the potential of the entire male as a meat producing animal. Evidence of this interest is indicated in the holding of a symposium entitled "Meat Production From Entire Male Animals" at the British Meat Research Institute, Bristol,

England (Rhodes, 1969). The research results reported at this conference generally showed the superiority of the intact male. Boars were reported to eat less, have a better FC, and to be a leaner than the traditional castrate. Earlier reports by Carroll et al. (1963); Charette (1961); Kroeske (1963); Teague et al. (1964) and Prescott and Lamming (1964) had made similar observations.

Martin (1969) in an extensive review summarizing recent publications comparing differential performance of boars and barrows concluded that castration had little influence on rate of gain in swine. However, Wong et al. (1968) found that boars exceeded barrows by 7% and gilts by 5% in ADG when either a 17% protein diet was fed throughout the experiment or a 17% protein growing diet and a 13% protein finishing diet were fed. Walstra (1969) found that barrows will grow faster than boars when fed at libitum and boars will grow faster than barrows when fed restricted rations.

Castration seems to have more influence on FC than it has on rate of gain. Most of the results obtained have demonstrated that boars require less feed per unit gain than barrows (Blair and English, 1965; Charette, 1961; Lidvall et al., 1964; Turton, 1969; Wismer-Pedersen, 1968). Walstra and Kroeske (1968) cited 22 different references from 10 countries which dealt with feed efficiency. Boars equalled or surpassed the feed efficiency of barrows in all of these studies.

Factors which may influence comparative results between boars and barrows are age and weight at castration or at slaughter, genotype of the animals, and level of nutrition (Turton, 1969). Prescott and Lamming (1967) found a significant interaction in growth rate between castration and level of dietary protein. Percentage of lean content was also influenced by these parameters. They suggest that lack of protein in the diets might alter some of these results due to the fact that the protein levels generally used were designed to meet the requirements of barrows and gilts and not those of boars.

## Effect of sex on carcass characteristics

Carcass measurements and composition have been reported to be influenced by sex. Gilt carcasses have been shown to be superior to barrow carcasses in most quality measurements (Robinson and Lewis, 1964; Duckworth et al., 1961). In general, less carcass fat has been reported as the main factor accounting for the superiority of the female (Johannson and Korkman, 1951; Friend and MacIntyre, 1970). Buck et al. (1962), reported that gilt carcasses were leaner than barrow carcasses in terms of a higher percentage of lean meat and larger loin eye muscle in addition to reduced measurements of backfat thickness. Sex has been reported by Spurr (1965) to have a major influence in carcass quality. Gilts were superior to barrows in length, backfat thickness and proportion of trimmed lean cuts. However, Bowland and Berg (1959) reported that gilts and barrows did not differ appreciably in length of carcass. According to Pearson et al. (1970) length of carcass is not considered to reflect the value of the carcass. The superiority of gilt carcasses as compared with barrow carcasses is also shown in other studies (Fredeen and Plank, 1963; Fredeen et al., 1964; Skitsko and Bowland, 1970). The influence of sex appears to vary relative to liveweight, with gilts maturing at earlier weights than barrows (Richmond and Berg, 1971b).

Most experiments have reported that boars are leaner than barrows at usual market weights (Martin, 1969; Martin et al., 1972). Because of the higher fat content in barrow carcasses, they have a higher dressing percentage than boar carcasses (Martin, 1969; Wismer-Pedersen, 1968). Boar carcasses are generally longer and have larger loin areas than castrates (Blair and English, 1965; Charette, 1961). Wong et al. (1968) reported that gilts exceeded barrows in longissimus dorsi area with boars being intermediate. In addition to the studies of Prescott and Lamming (1967) mentioned previously, Bayley and Summers (1968) and Fowler et al. (1969),

found that boars produced leaner carcasses with an increase in protein content of the diet. However, Hines (1967), in a study involving 449 pigs, concluded that sex (boars, barrows, gilts and spayed gilts) and limited feeding did not consistently alter comparative live performance or carcass characteristics.

Conflicting evidence exists on comparative ADG between sexes. These differences in results may be associated with the different systems of feeding used. When a liberal system of feeding is used little or no difference in rate of gain is observed, but when a system of restricted feeding is used boars and gilts will grow faster than littermate barrows. Boars require less feed per unit gain than barrows with gilts being intermediate. The superiority of boar and gilt carcasses over those of the barrow is outstanding. Boar and gilt carcasses have less fat and more lean than barrows. Level of dietary protein can be a factor influencing some of the results with boar carcasses, and to a lesser extent, gilt carcasses being increased in superiority to barrow carcasses when a high protein diet is fed.

## Boar Taint

Sex odor in intact male or cryptorchid pigs was reported over 35 years ago. Lerche (1936) reported an unpleasant odor in the carcass from boars or cryptorchids. This odor was also present in boar carcasses slaughtered 75 days after castration. Since 1936, numerous researchers have reported that fat from some boars possess a musk like smell which makes such meat unacceptable for human consumption (Bratzler *et al*., 1954; Martin, 1969; Self *et al*., 1967; Staun, 1971; Williams *et al*., 1963). However, some authors have found no difference in odor or flavor of meat from boars and barrows (Charette, 1961; Carroll *et al*., 1963; Walstra and Kroeske, 1968).

The odor of heated boar fat is now known to be due to the presence of a steroid ($5\alpha$-androst-16-ene-3-one) which has been isolated from boar fat. This

compound has the emperical formula of $C_{19}H_{28}O$ and was found to possess a pronounced perspirative urine-like odor characteristic of several androgen steroids of similar structure (Patterson, 1968a).

Different odors are associated with boar environment and with boar meat. Generally speaking all these odors have been described as boar odor, boar taint or sex odor. It has been reported by Patterson (1969) that the odor from the prepuce differs considerably from that of the heated fat, but both are described as boar odor, as is also the carcass odor of a freshly gutted mature animal.

Craig and Pearson (1959) and Dutt et al. (1959) have suggested that boar taint was strongest in the fatty tissue surrounding the penis and prepuce and that the preputial glands might be the source of the sex odor. Patterson (1967) separated, chemically, samples of fluid which gather in the preputial diverticulum. He showed that p-cresol accounted for over 90% of the phenols present in the fluid and after an olfactory evaluation concluded that p-cresol was the main constituent (except for ammonia) of the odor of the preputial fluid at its normal alkaline pH, but neither it nor other phenols appeared to be responsible for the taint of heated fat.

Craig et al. (1962) reported that sex odor was found to be water insoluble, ether soluble and definitely associated with the unpleasant smell of heated boar fat. Analysis of the unsaponifiable residue from boar fat in which the taint could be detected subjectively by smell, showed no differences from barrow fat in which no taint was detected (Williams and Pearson, 1965).

It has been suggested that the presence of boar odor could be detected most easily by heating the salivary glands (Gereke, 1935; Lerche, 1936). A more detailed examination (Patterson, 1968b) of the three salivary glands of boars, barrows and gilts has confirmed that the odor of the submaxillary salivary gland of boars is quite different from that of barrows or gilts, but that neither the parotid

nor sublingual glands produces this odor when heated. It was further demonstrated that one of the principal compounds responsible for this characteristic odor was 3 $\alpha$-hydroxy-5 $\alpha$ androst-16-ene closely related to the ketone found in the fat, but differing by possessing a hydroxyl group in place of the carbonyl at $C_3$ in the A ring of the molecule. Androstenone (5 $\alpha$ androst-16-ene-3-one) was also present in the extract, but in much smaller concentrations. A detailed experimental procedure to quantitatively estimate androstenone has been published by Patterson (1969).

Numerous experiments have been performed in attempts to discover the biosynthetic origin of androstenone. In in-vitro experiments involving testis and adrenal cortex tissue preparations, pregnenolone and progesterone have been found to be precursors of $C_{19}$ steroids (Katkov and Gower, 1968; Gower and Ahmad, 1967; Ahmad and Gower, 1968). The $C_{19}$-steroids, testosterone and dehydroepindrosterone (DHA) were ineffective as precursors (Ahmad and Gower, 1968). The origin and physiological significance of the substantial quantities of androstenone in boar fat is still largely unknown (Fuchs, 1971).

Elsley and Livingstone (1969) and Martin (1969) considered stage of maturity to be extremely important in relation to incidence of boar taint. They suggested taint incidence to be low in boars of 70 kg or under and that as the animal matured the probability of taint increased. Elsley (1968) reported that the percentage of boars in which taint was detected or suspected increased from 34% at 55 kg to 52% at 92 kg bodyweight. Self et al. (1957) indicated that about 75% of boars under 90 kg produced carcasses with acceptable cooking aroma. However, Wismer-Pedersen et al. (1969) concluded that boar taint was not related to age in 1907 boars slaughtered after use in boar service stations. Staun (1971) reported no change in sex odor and taste of boars slaughtered at 55, 70, 80 or 100 kg liveweight. The same relationship between sex odor and taste was observed for age at slaughter.

Williams, Pearson and Webb (1963) found that in commercial boar carcasses of market weight, 28% had strong odor, 36% had slight odor and 36% were free from odor. Wood (1972) reported that 44% of the boar carcasses that he evaluated were free of taint as evaluated by a trained panel. Of the tainted carcasses, 12% were reported as slightly tainted, 25% as moderate and 19% as having pronounced taint. Fat from cryptorchids was found to have a higher probability of taint as only 34% of the cryptorchids carcasses were found to be free of taint.

Controversial reports have been presented on the acceptability of boar meat. Bratzler et al. (1954) reported that quality of pork produced by boars was inferior in all respects. Acceptability tests showed that the boars produced pork that had a definite "off" flavor and odor. Meat from boars has been reported to be less acceptable than meat from barrows (Cahill et al., 1959; Christian and Turk, 1957). Elsley (1968) reported no taint in carcasses from barrows and gilts according to an olfactory evaluation from a trained panel. However, Williams et al. (1963) reported the presence of taint in 64% of boars, 1% of sows, 15% of barrows and 5% of gilts. Staun (1971) also reported taint to be present to a lesser extent in sows and barrows in comparison with boars. Blair and English (1965) noted stronger average odors from boars but no major difference in flavor of meat between carcasses from boars and barrows. However, Walstra and Kroeske (1968) found no difference in odor and flavor of meats from boars and barrows. Furthermore, Martin et al. (1968) reported pork from boars to be superior in texture and tenderness and to have a flavor equally as good as pork from barrows and gilts.

Subjective tests for odor evaluation have been used extensively over the past few years. The method of selection and training the panelists and the sensitivity of the members of the panel to the odor have given rise to considerable controversy. Different methods of heating and smelling the fat have been tried. Elsley and Livingstone (1969) described a method in which fat samples were placed in individual

aluminum foil dishes which were gently heated to approximately 110°C. Volatilazation of sex odor was found by Craig et al. (1962) to be greatest at 100-108°C. A method using a soldering iron as a source of heat was developed by Jarmoluk et al. (1970). The tip of the soldering iron is placed in direct contact with the fat. A great variety of scoring systems have also been used, from very complicated systems to the simplest 'yes' or 'no'.

Fuchs (1971) reported a high correlation coefficient (r = .75) between the sensory evaluation of fat and the androstenone content. Evaluation of the sex odor was made by a panel of eight members using the soldering iron method of Jarmoluk et al. (1970). High correlations were also found by Tucker (1971) between androstenone content and evaluation by a panel consisting of 4 members smelling the odor from fat placed in aluminum foil dishes heated to 110°C.

Certain individuals are unable to detect the unpleasant smell that arises when fat from boars is heated. According to Rhodes (1969), one study showed that 7.6% of women and 44.3% of men were unable to detect boar taint. Elsley (1968) conducted tests involving about 200 persons to assess the strength and characteristics of boar taint. He reported that 25% of the individuals considered boar odor to be very unpleasant, 44.5% considered it as unpleasant, 21.5% were neutral and 9% liked the odor.

Suggestions have been made on the possibility of utilizing boar meat in products to be eaten cold (Allen et al., 1970). Pearson et al. (1969) suggested that boar meat may be acceptable in warm loaf items if they are heated in kitchens separate from the dining units.

Most of the methods used to detect taint are based on sensory evaluation. Because it is a subjective approach it has caused discrepancies between experiments. The question is whether to use a trained or untrained panel or a consumer's approach. A reasonably large proportion of the general public cannot smell the taint of heated

boar fat and, furthermore, evidence indicates that a small percentage of the public like the odor. A partial explanation of the disagreement between experiments could be because tests based on domestic, kitchen conditions or those based on taste panel evaluations could provide answers different from those obtained from laboratory odor tests (Elsley, 1968).

## Effects of Diethylstilbestrol

Extensive use is being made of synthetic and purified estrogens, androgens, progestogens and growth hormones to stimulate the growth and fattening of meat producing animals. Diethylstilbestrol (DES), a synthetic steroid-like hormonal compound, has been used extensively in animal production.

The increased rate of gain and improved feed efficiency resulting from administration of DES to domestic ruminants is a recognized fact. The preponderance of the data indicates that these effects are associated with increased protein anabolism and reduced lipogenesis (Gassner *et al*., 1958; Hammond, 1958). It would appear that administration of estrogens act by increasing the output of growth hormone, thus making the animal temporarily younger and emphasizing bone and muscle growth instead of that of fat (Lawrie, 1966).

Most research workers support this theory of an anabolic protein effect but they do not all agree on the mechanism of action. Trenkle (1970) reported that feeding stilbestrol increased significantly the plasma growth hormone. Other workers have suggested that stilbestrol administration resulted in an increased pituitary mitotic activity, pituitary weight and serum growth hormone (Lloyd *et al*., 1971). The results obtained in pigs when estrogens have been fed or implanted have not been as consistently positive as those with ruminants.

### Feeding Diethylstilbestrol

Recognition of the growth promoting effect of DES in pigs goes back 20

years when Braude (1950) reported that feeding 30 mg DES per day to barrows resulted in a faster ADG and better FC than that obtained with littermate controls. However, other workers (Beeson et al., 1955; Perry et al., 1954; Taylor et al., 1955) have not found any response to DES feeding at different levels to pigs. The apparent differences in response to oral DES may be due to a much higher dosage used in the former case (30 mg DES/day as compared with less than 5 mg DES/day).

Most researchers agree that there is a trend to produce leaner carcasses when DES is fed. Braude (1950) reported that DES-treated pigs were leaner than controls, indicating that the increase in weight was not due to the deposition of fat. Although no statistical differences were reported by Beeson et al. (1955) there was a trend for the DES-treated animals to produce leaner carcasses.

Some workers have reported abnormalities when DES was fed either to barrows or gilts. The feeding of stilbestrol resulted in enlarged teats in both males and females and resulted in swelling of the vulva in females (Perry et al., 1954). Feeding different levels of DES to gilts was reported by Taylor et al. (1955) to increase the diameter of the cervix, size of the vulva and to cause enlargement of the teats.

The oral administration of methyltestosterone (MT) (20 mg/animal/day) or DES (2 mg/animal/day) to pigs with or without terramycin (oxytetracycline) was reported by Beeson et al. (1955) not to improve growth rate or feed efficiency. Baker et al. (1967) reported that a combination of DES (2.2 mg/kg feed) and MT (2.2 mg/kg feed) when fed to finishing barrows and gilts improved feed efficiency. Jordan et al. (1965); Thrasher et al. (1967); and Wallace and Lucas (1969) have all reported that DES + MT decreased the gains of barrows. However, Bidner et al. (1972) in one experiment reported that DES + MT treated pigs gained more efficiently than untreated controls regardless of sex, but in a second experiment found that DES + MT treatment depressed the gains of barrows but stimulated the gains of

gilts. In both of their experiments they found that DES + MT significantly decreased carcass fat and increased measures of muscling, with the differences being greater for barrows than for gilts. Similar results were reported by Baker *et al*. (1967).

### Implanting Diethylstilbestrol

Implantation of 12 or 24 mg DES in the ear did not consistently stimulate gains of growing-fattening pigs as was observed with beef cattle and lambs (Dinusson *et al*., 1951). They observed that control animals (not treated) required from 5.2 to 13.7% more feed/kg gain than did the treated pigs. A growth depressing effect upon young boars after DES implantation was reported by Pearson *et al*. (1952). No significant differences between stilbestrol or testosterone implanted pigs and the non-implanted controls were found for live performance (Woehling *et al*., 1951). Similar results were obtained by Cahill *et al*. (1960) who found only minor effects on growth rate and feed efficiency after DES implantation. Heitman *et al*. (1957) reported that implantation of 30 mg stilbestrol in 26 to 33 kg liveweight feeder pigs resulted in reduced gains, reduced feed intake and a trend toward better feed utilization during the feeding period. On the other hand, the same treatment in heavyweight feeders (49-60 kg) had no effect on gains.

Teague *et al*. (1964) conducted seven trials to determine the effectiveness of implanting boars with DES. Feedlot performance as well as carcass and organoleptic characteristics of market weight (93-98 kg) barrows, boars and boars implanted with either 48 mg DES at 70 kg liveweight or 96 mg at 66, 70, or 75 kg were compared. The rate of gain of boars implanted with 96 mg DES at 70 kg was significantly faster than that of unimplanted controls and of barrows. DES treatment also resulted in an improvement in efficiency of FC. Similar results were obtained by Echternkamp *et al*. (1969) and Plimpton *et al*. (1967).

A possible protein anabolic effect of stilbestrol in pigs has been suggested. Heitman et al. (1957) reported that early implanted animals had leaner carcasses than castrates with late treated animals being intermediate in this respect. However, Pearson et al. (1952); and Woehling et al. (1951) reported no significant effects on carcass measurements with stilbestrol implantation. Teague et al. (1964) reported that barrow carcasses were shorter and fatter than control boars or boars implanted at 70 kg with either 48 or 96 mg DES. Significantly longer and leaner carcasses and higher yield of primal cuts have been reported for boars implanted with 96 mg DES at 70.4 kg liveweight (Plimpton et al., 1965; Plimpton et al., 1967).

Larger longissimus dorsi muscle areas have been found with implantation of DES, (Cahill et al., 1960; Plimpton et al., 1965). However, implantation has been reported by Plimpton et al. (1971) not to significantly affect measurements of tenderness, juiciness, color, marbling, pH, ether extract, moisture or protein content of the longissimus muscle.

Dinusson et al. (1951) reported that implantation of gilts and barrows with 12 or 24 mg DES produced some mammary development and teat growth which was greater in the former. A mild nymphomaniac response and extreme swelling of external genitalia were observed in gilts. In barrows there was a restored ability for erection of the penis and a renewal of sex desire. Boars implanted periodically over a period of 107 days have been reported by Pearson et al. (1952) to be fertile and to manifest normal sexual behaviour. A slight decrease of the seminiferous tubule diameter in boars was reported by Palmer et al. (1971), 35 days following implantation of 96 mg DES. Implantation also decreased significantly the weight of the prostate gland and increased the adrenal gland weight (Echternkamp et al., 1969).

It has been well established that implantation with DES reduces the degree of taint in the fat from boars. Teague et al. (1964) reported that sex odor and

flavor at the 10th rib in loin chops were significantly reduced. In no case were the carcasses from boars implanted with 96 mg DES at 70 kg condemned because of odor or flavor scores. Boar odor intensity in unimplanted boars, ranging from 70.3 to 127.0 kg liveweight, was found by Echternkamp et al. (1969) to be positively correlated ($P < 0.01$) with plasma androgen activity and androgen-estrogen ratio, but implantation of 96 mg DES at a liveweight of 70.3 kg significantly ($P < 0.01$) reduced organoleptic odor and flavor scores at a liveweight of 127.0 kg. Reduction of boar taint has been reported (Plimpton et al., 1971) to persist for at least 10 weeks after implantation with 96 mg DES at 70.4 kg. Strong odor and flavor was found in 37.8% of the control boars, 6.7% of the implanted boars and 2.2% of the barrows.

Diethylstilbestrol has been shown to decrease the amount of taint present in boar fat, although the mechanism of action is not clear. Some improvement in daily gain of boars has resulted from implantation with 96 mg DES. Normal sexual behaviour after implantation of boars with DES has been reported. Less satisfactory results have been obtained by feeding DES. Anatomical and physiological abnormalities have been found, mainly when DES is fed, although some evidence exists that these abnormalities also occur when DES is implanted in barrows or gilts.

## Effects of Male Castration

Castration is a long established management technique with domestic animals that consists in the extirpation of the testicles in the male or the ovaries in the female, eliminating in this way the mating instincts and the reproductive ability of the animals. According to Quijandria and Shiva (1965); the major effects from castration are:

- Increased quality of meat, due to a better fat deposition;
- Easier and better handling of the animals because of the disappearance

of sexual drive and aggressiveness, and;

- Prevention of indiscriminate breeding.

Numerous researchers have reported a better performance and carcass composition of entire males compared with castrates. Cobic (1968); Arthaud _et al_. (1969); Champagne _et al_. (1969); Prescott and Lamming (1964); have reported a higher ADG of bulls as compared with castrates and in most cases a better feed efficiency. Hedrick (1968) and Brannang (1966); reported advantages of about 15% for ADG of bulls over steers. Bidart _et al_. (1970) found even wider differences when feed consumed was expressed in gain of edible product. Bulls consumed 6.0 Mcal. of digestible energy per kg of edible product compared with 12.8 Mcal. for steers. Similar results have been reported for rams and wethers. Jacobs (1970) and Deweese et al. (1969) found rams to be 12 to 15% more efficient in converting feed to live gain than wethers. In most of the work reviewed by Field (1971); it was reported that there was less fat depth in the ram carcasses compared with wether carcasses.

Walstra and Kroeske (1968) reported that boars grew faster than barrows. However, no significant differences in daily gain between boars and barrows were reported by Robertson et al. (1965). Boars have been reported to utilize feed more efficiently than castrates (Blair and English, 1965; Walstra and Kroeske, 1968). Numerous researchers have reported that boars have leaner carcasses than barrows, using less feed in the process (Cahill _et al_., 1960; Charette, 1961; Martin, 1969; Staun, 1971; Teague _et al_., 1964; Texier _et al_., 1970).

Castration of the male pigs has been considered indispensible in pork production, because of the possibility of taint being present in the carcasses. As discussed previously, some of the factors that will affect differences in rate of gain between boars and barrows are age and weight at castration and slaughter, breed or genotype and level of nutrition (Turton, 1969).

Bratzler et al. (1954) concluded that castration at 6 months of age (82 kg liveweight), five weeks (21-44 days range) prior to slaughter eliminated the undesirable odors associated with boar meat. Intact boars and boars castrated at 82 kg liveweight had a higher percentage of lean in the loin, less backfat, longer body length and increased carcass preferred cut yield than boars castrated either at 45 or 64 kg liveweight or barrows. Quality of the pork produced by boars was considered inferior in all respects. Rate of gain and amount of gain per unit of feed was not affected by delayed castration or by non-castration.

Norrish et al. (1968) compared partial castration at 6 and 26 days of age according to the Baiburtcjan's method and complete castration at 6, 26 and 76 days of age and at 68 kg liveweight and found no significant differences in growth rate or in any carcass measurements studied (length, backfat thickness, loin eye area, percent lean in the ham face and percent ham of the side). Of 22 carcasses from partial castrates, 15 were detected as having odor. Charette (1961) reported that acceptability tests showed that sex or age of castration did not affect the flavor, odor or tenderness of the meat from boars, barrows and gilts.

Swierstra (1968) found no significant differences between partial castration (Baiburtcjan's method) and the conventional castration method for age at slaughter, dressing percentage, ham weight, loin eye area, average backfat thickness and carcass length. Forty-seven percent of the partial castrates were graded as ridglings (cryptorchids) and their average sale value was 19% less than that of the complete castrates.

Staun (1971) reported no significant differences between entire males, partially castrated males (Baiburtcjan's method) and females in ADG, FC or carcass quality. When comparing males with normal castrates, the effect of castration was significant ($P < 0.01$), as more feed and more days were required by the castrated males to reach 90 kg as compared with intact males. It appears

that castration decreases the carcass quality, and also increases the feed consumption per kg gain. There were no significant differences between treatments in texture of the meat. No changes in sex odor and taste of boars at 55, 70, 85 and 100 kg liveweight were detected. Thus, the chances of sex odor and characteristic boar meat taste are present as frequently at 55 kg as at 100 kg.

In order to examine how sexual odor and taste vary with age, when the boars are slaughtered at the same liveweight, further investigations were carried out by Staun (1971). The boars were given different feeding levels during the growth period from 20 to 90 kg so that the four groups of animals reached market weight (90 kg) at approximately 20 day intervals. Results indicated similar odor intensity scores in all groups. He concluded that neither the weight nor the age at which the boars are slaughtered is of decisive importance in determining the intensity of sex odor. The results also indicated that sex odor may be found, but to a lesser extent, in sows and in castrates.

Rhodes and Patterson (1971) reported that entire male pigs were superior in lean content, having about 10% of their carcass weight transferred from the subcutaneous fat to total lean. Furthermore, this improvement was accompanied by an improvement in FC of 8%, so the overall advantage in terms of lean meat produced per unit of feed amounted to 29 percent. No differences were found between complete castrates and partial castrates in which the testes were removed with retention of the epididymides or in which the testicular parenchyma was removed with retention of the tunica vaginalis propria. These results indicate that the site of biosynthesis of androstenone itself or of its precursor lies with the source of the androgenic hormones in the testicular tissue and that the functions of the tunic, epididymides and accessory glands are secondary.

Field (1971) in a extensive review of effects of castration on meat production reported that, in general, the difference in growth rate between boars and barrows

is not as great as the difference between rams and wethers or bulls and steers. Differences in FC are small but clearly favoured the boars. Boars have less fat than barrows. Differences in consistency of fat existed between barrows and sexually mature boars. Fat from heavy boars was softer and contained more oleic acid than fat from corresponding barrows. He concluded that because of the sex odor in warm boar meat and the small economic advantage of boars in terms of growth rate and FC, it is unlikely that boars will be produced for meat. Nevertheless, boar meat can be utilized under specialized conditions. In addition, meat from boars which lack sexual maturity (those under 70 kg liveweight) may eventually find a place in some markets.

As far as comparative growth rate is concerned there are species differences between the castrate and the intact animal. Experiments have demonstrated a clear superiority of the bull and the ram over the traditional castrates. In pigs this superiority in rate of growth is less marked, varying considerably among studies. Intact male pigs have been found to eat less, to be more efficient and to have leaner carcasses than barrows in almost all studies.

# PART 1

## Preliminary Study with Intact and Castrate Male and with Female Rats

### Introduction

The superiority of male animals over the traditional castrate is well documented. Bulls have a better growth rate and require less feed per unit gain than do steers (Brannang, 1966; Hedrick, 1968). Similarly, Field (1971) reported that rams grow faster than castrates, requiring less feed in the process (Prescott, 1969). Rate of gain in pigs has not been influenced as consistently by castration but general agreement exists regarding the superior feed efficiency of boars over barrows (Walstra and Kroeske, 1968). A factor which may affect comparative results is plane of nutrition (Cobic, 1968). No experiments comparing the performance of intact male and castrated male rats have been found in the literature.

The objectives of this study were to evaluate the effects of sex and dietary protein level on the live performance and energy and nitrogen metabolism of intact male and female and castrated male laboratory rats fed diets containing either 18% protein or 13% protein throughout the experiment. A further objective was to evaluate the rat as a possible pilot animal for related studies with pigs.

### Materials and Methods

Thirty-six rats (12 males, 12 females and 12 castrate males) of the Sprague Dawley University of Alberta strain were alloted at an average weight of 109 gm to two diets containing either 18 or 13% protein (Table 1). These diets were fed throughout the experiment. Castration was performed approximately 5 days before starting the experiment at an average age of 5 weeks. The rats were individually housed in stainless steel (24 x 20 x 18 cm) cages throughout the experiment. Rats were allowed food *ad libitum* and water was available at all times.

TABLE 1. Formulation and composition (as fed basis) of diets in rat experiments.

| Calculated Protein, %: | 18 | 13 |
|---|---|---|
| Ingredients % | | |
| Barley | 39.7 | 70.3 |
| Wheat | 40.0 | 20.0 |
| Soybean meal (44%) | 15.0 | 4.0 |
| Herring meal (72%) | 2.0 | 2.0 |
| Ground limestone | 1.0 | 1.2 |
| Dicalcium phosphate | 1.5 | 1.7 |
| Iodized salt | 0.4 | 0.4 |
| Trace mineral mix[1] | 0.1 | 0.1 |
| Zinc sulfate | 0.05 | 0.05 |
| Vitamin mix[2] | 0.15 | 0.15 |
| Vitamins A, D, and E[3] | + | + |
| Aurofac-10 | 0.1 | 0.1 |
| Composition (by analysis) | | |
| Digestible energy / kcal/kg | 3235 | 3261 |
| Crude protein | 18.2 | 15.0 |

[1] The mineral mix supplied the following per 100 kg diet: cobalt carbonate 229 mg; copper sulfate 2.4 g; ethylene diamine dihydroiodide 110 mg; ferrous carbonate 23.3 g; manganous oxide 4.8 g; zinc oxide 297 mg; ground limestone 686 g.

[2] The B-complex vitamin mix supplied the following per 100 kg diet: riboflavin 440 mg; calcium pantothenate 880 mg; niacin 1980 mg; choline chloride 2130 mg; folic acid 13.2 mg; vitamin $B_{12}$ 990 µg.

[3] The following vitamins were supplied per 100 kg diet: vitamin A 495,000 I.U.; vitamin $D_2$ 50,000 I.U.; vitamin E 1100 I.U.

[4] Calculated from digestibility studies with rats.

Food consumption and rat weights were recorded at the start of the experiment and at weekly intervals thereafter until the end of the trial 6 weeks later.

Energy and nitrogen digestion and retention studies were carried out 2 weeks after the start of the experiment. Feces and urine were collected every day during the 4-day metabolism trial. After the daily collection, urine was stored at 38°C until the 4th day of collection when the urine collections were mixed. A 5 ml aliquot of urine was used in the nitrogen (N) determination. The remainder of the urine was freeze-dried and used for energy determinations. Feces were also stored during the collection period after which they were mixed and dried for approximately 72 hr in an oven at 60°C. Prior to the nitrogen and energy analyses, mixed feces were ground through a 0.317 cm mesh screen. Combustible energy was measured for feed, feces and urine using a Parr adiabatic oxygen bomb calorimeter. Nitrogen determination was carried out on feed, feces and urine using the Kjeldahl method (AOAC, 1965) with protein being calculated from N x 6.25.

Analyses of variance were used to statistically analyze the data. A 2 x 3 factorial design was used including two dietary protein levels and three sexes. The parameters that were found to be significantly different were further analyzed using Duncan's multiple range test (Steel and Torrie, 1960).

## Results and Discussion

Male rats ate more ($P < 0.01$), averaging 19.1 g/day, than either females or castrate males that averaged 16.7 and 17.2 g/day, respectively (Table 2).

ADG was significantly ($P < 0.01$) influenced by sex. Male rats had a rate of gain averaging 4.42 g/day which was greater than castrate males that averaged 3.76 g/day, which in turn was greater than females that averaged 2.89 g/day. Elliot and Bowland (1972) reported significantly ($P < 0.05$) higher daily gains for male rats compared with female rats at 4 and 8 weeks after weaning. Similarly,

TABLE 2. Means for live performance of rats receiving either an 18% or 13% protein diet.

| Sex | Males | Females | Castrates | | |
|---|---|---|---|---|---|
| Protein Level % | | | | 18 | 13 |
| Av. daily food g | 19.1 a | 16.7 b | 17.2 b | 17.5 | 17.8 |
| Av. daily gain g | 4.42 a | 2.89 b | 3.76 c | 3.67 | 3.71 |
| Food/ g gain g | 4.32 a | 5.80 b | 4.59 a | 4.90 | 4.91 |

a,b Sex means with the same letter are not significantly different ($P < 0.01$).

Bowland and Standish (1966) found that male rats will grow faster than females.

In the present study, intact male rats were more efficient ($P < 0.01$) in FC compared with females averaging 4.32 and 5.80 g food/g gain, respectively. Castrate males were found to be intermediate in FC, but not significantly different from intact males. O'Grady and Bowland (1972) reported that male rats ate more and had a better feed efficiency than females. Similar results were found by Bowland and Standish (1966), regardless of the diet used. No significant differences in food intake, ADG or FC were found to be associated with dietary protein level.

No significant differences between sexes or protein level were found for digestibility and retention of N and energy (Table 3). However, intact male animals tended to digest and retain more N and energy per day than either females or castrates. This may be explained by the higher feed intake of males compared with females and castrates. Bowland and Standish reported no significant differences in digestibility or retention between female and intact male rats, but there seems to be no information in the literature on N and energy digestibility of castrated male rats.

Percentage of the digested N (DN) which was retained was significantly influenced by dietary protein. Animals fed the low protein diet averaged 78.5% N retained/DN which was higher ($P < 0.05$) than rats fed the high protein diet that averaged 71.2% for this criterion. Dietary protein level also influenced the daily N retained which was higher in rats fed the 18% protein diet. Daily digestible and metabolizable energy was found to be higher ($P < 0.05$) in animals fed the low protein diet.

Intact male rats consumed more food per day than castrates which in turn ate more than females. Significant differences in growth rate between the intact males as compared to castrates or females were observed. Female rats grew more slowly and required more food per unit gain than did males or castrates. On a

TABLE 3. Digestibility and retention data for nitrogen (N) and energy for intact male, female and castrate male rats.

| Sex<br>Protein Level % | Males | Females | Castrates | 18 | 13 |
|---|---|---|---|---|---|
| Digestible N (DN) % | 81.5 | 79.7 | 82.0 | 81.3 | 80.7 |
| N retained (NR)/N intake % | 60.4 | 60.1 | 61.8 | 58.1 | 63.5 |
| NR/DN % | 73.8 | 75.6 | 75.2 | 71.2 | 78.5* |
| DN/day mg | 429 a | 374 b | 380 b | 409 | 380 * |
| NR/day mg | 319 a | 267 b | 299 ab | 303 | 287 |
| | | | | | |
| Digestible energy (DE) % | 82.5 | 83.4 | 84.1 | 83.1 | 83.6 |
| Metabolizable energy (ME) % | 81.4 | 82.4 | 83.0 | 81.8 | 82.8 |
| DE/day kcal | 63.2 a | 54.2 b | 57.7 ab | 55.0 | 61.7** |
| ME/day kcal | 62.4 a | 53.6 b | 57.0 ab | 54.2 | 61.1** |

a,b Sex means with the same letters or no letters are not significantly different ($P < 0.01$).

* Significantly different at ($P < 0.05$).

** Significantly different at ($P < 0.01$).

percentage basis, castrated males digested and retained more nitrogen and energy than either intact males or females. Although there are differences in performance between castrated and intact male rats, the order of these differences does not appear to be similar to that reported in the literature for castrated and intact male pigs. It seems doubtful that the rat is useful as a pilot test animal for the pig in studies comparing performance of castrated and intact males. The inability to castrate male rats at an age which is physiologically equivalent to that at which male pigs are usually castrated also limits the use of rats as a pilot species for pig studies.

# PART 2*

## Performance of Boars, Barrows and Gilts Fed Two Levels of Protein

### Introduction

Numerous researchers have reported that sex of pigs and dietary protein may influence performance and carcass composition (Bayley and Summers, 1968; Fowler *et al*., 1969; Martin, 1969; Prescott and Lamming, 1967; Staun, 1971; Walstra and Kroeske, 1968; Wismer-Pedersen, 1968; Wong *et al*., 1968). Some of these studies have shown that boars have a superior rate of gain, improved feed conversion and leaner carcasses than barrows with gilts usually being intermediate in these criteria. Levels of dietary protein and methods of feeding may be factors influencing comparative results between sexes.

The objectives of this study were to evaluate the effects of sex and dietary level on the performance, carcass composition and fat composition of boars, barrows and gilts fed diets containing either 18% protein throughout or 16% protein in the growing (up to 50 kg) diet and 13% protein in the finishing diet to market weight of 90 kg.

### Materials and Methods

Forty-eight pigs, 16 each of boars, barrows and gilts, were allotted at an average initial weight of 9.5 kg for boars and barrows and 10.9 kg for gilts, and an average age of 41 days, to two treatment groups based on dietary protein level (Table 4). Initial weight differences between sexes were not significant. Each

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* The material in Part 2 of this thesis has been published in the September, 1972, issue of the Canadian Journal of Animal Science: Newell, J.A. and Bowland, J.P., 1972. Performance, carcass composition, and fat composition of boars, gilts, and barrows fed two levels of protein. Can. J. An. Sci. 52: 543-551.

TABLE 4. Allotment of pigs in boar, gilt and barrow comparisons when different dietary protein levels were fed.

| Treatment no. | Sex of pigs | Calculated level of dietary protein % Growing period, start to 50 kg | Calculated level of dietary protein % Finishing period, 50-90 kg |
|---|---|---|---|
| 1 | Boars | 18 | 18 |
| 2 | Boars | 16 | 13 |
| 3 | Gilts | 18 | 18 |
| 4 | Gilts | 16 | 13 |
| 5 | Barrows | 18 | 18 |
| 6 | Barrows | 16 | 13 |

of the three sexes was divided into four lots of four animals each, with two lots fed an 18% protein diet throughout and the other two fed a 16% protein growing diet and a 13% protein finishing diet (Table 5). Calculated values for the ten essential amino acids and for calcium and phosphorus in the diets are listed in Table 6. The barrows were castrated 2 days after they were placed on experiment, thus allowing equal weight allotment of boars and barrows. Each lot of pigs was housed in a 4.1 x 1.5 m pen (gutter included), with free access to feed and water. The boars were housed in pens that were not adjacent to or across the center aisle from pens containing gilts. However, because of space limitations and barn design it was not possible to place the boars in a barn where there were no gilts housed.

Individual pigs were marketed during the week in which they reached 90 kg liveweight, except that the fourth pig in a lot was shipped when the third pig reached 90 kg. Grade Valuation and Canadian Record of Performance (ROP) measurements as described by Bowland (1971) were obtained on all carcasses. Fat samples for fatty acid analyses were obtained from the shoulder from all carcasses. Methods of fatty acid analyses were as described by Elliot and Bowland (1968). Twenty-four (16 boars, 4 barrows, and 4 gilts) of the 48 carcasses were returned to the Department of Animal Science Meats Laboratory for carcass dissection (Richmond and Berg, 1971a) and analyses. The left side of the carcass was used for muscle dissection. As previous complete dissections of barrow and gilt carcasses had been conducted in the Meats Laboratory, it was considered necessary to dissect only sufficient carcasses from these two sexes to allow comparison with the boar carcasses. The gilt and barrow carcasses were selected at random within pens within the two protein treatment groups. The eight boar carcasses used for complete dissection were similarly selected. As complete dissection is a very laborious procedure, it was considered unnecessary to dissect all 16 boar carcasses. For all 24 carcasses, six muscles were dissected; semitendinosus (S), gracilis (G), longissimus dorsi (LD),

TABLE 5. Formulation and composition (as-fed basis) of diets in boar, gilt and barrow comparisons when different dietary protein levels were fed.

| Calculated Protein, %: | 18 | 16 | 13 |
|---|---|---|---|
| Ingredients % | | | |
| Barley | 39.7 | 54.5 | 70.3 |
| Wheat | 40.0 | 30.0 | 20.0 |
| Soybean meal (44%) | 15.0 | 10.0 | 4.0 |
| Herring meal (72%) | 2.0 | 2.0 | 2.0 |
| Ground limestone | 1.0 | 1.1 | 1.2 |
| Dicalcium phosphate | 1.5 | 1.6 | 1.7 |
| Iodized salt | 0.4 | 0.4 | 0.4 |
| Trace mineral mix[1] | 0.1 | 0.1 | 0.1 |
| Zinc sulfate | 0.05 | 0.05 | 0.05 |
| Vitamin mix[2] | 0.15 | 0.15 | 0.15 |
| Vitamins A, D, and E[3] | + | + | + |
| Aurofac-10 | 0.1 | 0.1 | 0.1 |
| Composition (by analysis) | | | |
| Digestible energy/kcal/kg | 3254 | 3203 | 3148 |
| Crude protein % | 18.1 | 16.5 | 13.9 |

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[1] The mineral mix supplied the following per 100 kg diet: cobalt carbonate 229 mg; copper sulfate 2.4 g; ethylene diamine dihydroiodide 110 mg; ferrous carbonate 23.3 g; manganous oxide 4.8 g; zinc oxide 297 mg; ground limestone 686 g.

[2] The B-complex vitamin mix supplied the following per 100 kg diet: riboflavin 440 mg; calcium pantothenate 880 mg; niacin 1980 mg; choline chloride 2130 mg; folic acid 13.2 mg; vitamin $B_{12}$ 990 ug.

[3] The following vitamins were supplied per 100 kg diet: vitamin A 495,000 I.U.; vitamin $D_2$ 50,000 I.U.; vitamin E 1100 I.U.

[4] Calculated from digestibility studies with boars, barrows and gilts.

TABLE 6.[1] Calculated[2] essential amino acids and major mineral composition of diets.

| Protein % | 18* | 16 | 13* |
|---|---|---|---|
| Amino Acids | | | |
| Arginine | 1.07 | .93 | .71 |
| Histidine | .45 | .40 | .32 |
| Isoleucine | .74 | .66 | .54 |
| Leucine | 1.37 | 1.24 | 1.04 |
| Lysine | .95 | .80 | .58 |
| Methionine | .30 | .28 | .24 |
| Phenylalanine | .91 | .85 | .76 |
| Threonine | .65 | .58 | .48 |
| Tryptophan[3] | .23 | .21 | .19 |
| Valine | .87 | .81 | .72 |
| Minerals | | | |
| Calcium | .91 | .95 | 1.02 |
| Phosphorus | .72 | .73 | .73 |

[1] This table was not included in the publication.

[2] As a percentage of the diet.

[3] Calculated values for tryptophan.

* Values in these two columns are by analysis using a Technicon Amino Acid Analyzer. In the column under 16% protein, values for amino acids are calculated by extrapolation.

obliquus abdominis internus (OAI), extensor carpi radialis (ECR), and rhomboides (R). These muscles were analyzed for dry matter, protein, fat and ash and used as parameters for treatment comparisons.

Analysis of variance using a computer program for a factorial arrangement in a completely randomized design was used in statistical analyses of the data. Sources of variation were three sexes and two protein levels. Treatments were tested against pens in treatments, and pens in treatments were tested against animals in pens. This analysis follows the procedure outlined under methods for overcoming difficulties due to pen effects (Henderson, 1969). Feed efficiency and average daily feed were analyzed using pen means as individual data were not obtained. Because of unequal subclass numbers, total percentages of fat, bone, and muscle and muscle analyses were analyzed using analysis of variance of unweighted means with error term obtained by adjustment of individual mean squares (Bancroft, 1968). When there were significant differences in sex means, a one-way analysis was used to allow calculation of treatment differences by Duncan's multiple range test.

## Results and Discussion

### Feed Intake (Table 7)

During the growing period to 50 kg liveweight, feed intake was influenced by sex ($P < 0.05$), boars eating less than barrows, and gilts having an intermediate feed consumption that was not different from either boars or barrows. For the finishing period (50-90 kg) feed intake was not significantly influenced by sex. There was no significant influence on feed intake for the overall experiment but the trend established in the growing period still existed. For the overall experiment boars ate an average of 2.17 kg of feed per day compared with 2.38 kg consumed by gilts and 2.48 kg consumed by barrows. These results agree with those of Blair

TABLE 7. Means of live performance for boars, gilts and barrows fed two levels of protein

| Sex | Boars | Gilts | Barrows | | |
|---|---|---|---|---|---|
| Dietary Protein % | | | | 18 | 16-13 |
| No. animals | 16 | 16 | 16 | 24 | 24 |
| Initial-50 kg | | | | | |
| Av daily feed, kg | 1.63A | 1.80AB | 1.90B | 1.79 | 1.76 |
| Av daily gain, kg | 0.62 | 0.65 | 0.67 | 0.67 | 0.62** |
| Feed conversion, kg/kg | 2.63 | 2.77 | 2.84 | 2.66 | 2.83* |
| 50-90 kg | | | | | |
| Av daily feed, kg | 3.01 | 3.09 | 3.29 | 3.14 | 3.12 |
| Av daily gain, kg | 0.87A | 0.80B | 0.81B | 0.86 | 0.79** |
| Feed conversion, kg/kg | 3.46A | 3.86B | 4.06B | 3.68 | 3.94 |
| Overall: Initial-90 kg | | | | | |
| Av daily feed, kg | 2.17 | 2.38 | 2.48 | 2.36 | 2.32 |
| Av daily gain, kg | 0.72 | 0.72 | 0.73 | 0.75 | 0.69** |
| Feed conversion, kg/kg | 3.01A | 3.31B | 3.40B | 3.16 | 3.36* |

A, B Sex means with the same letter or no letters are not significantly different ($P < 0.05$).

* Significantly different at $P < 0.05$.

** Significantly different at $P < 0.01$.

and English (1965) who found lower feed intake for boars in comparison with barrows. Feed intake was not influenced by protein level and there was no interaction between sexes and protein level.

Rate of Gain (Table 7)

For the overall experiment, sex did not significantly influence average daily gain. Barrows gained 0.73 kg, boars 0.72 kg, and gilts 0.72 kg per day. However, boars gained more rapidly ($P < 0.05$) than gilts or barrows in the finishing period. Robertson et al. (1965) found no significant difference in daily weight gain between boars and barrows. However, Walstra and Kroeske (1968) reported that boars grew faster than barrows. Protein level had a significant influence ($P < 0.01$) on average daily gain, which was 0.75 kg for the pigs fed the 18% protein diet throughout and 0.69 kg for those fed the 16-13% protein diet.

There was a significant interaction in rate of gain between dietary protein level and sex for the overall experiment. The boars, and to a lesser extent the gilts, responded to higher protein levels in terms of rate of gain; the barrows were not influenced in this criterion by dietary protein level. The average daily gains of the pigs ranged from a maximum of 0.77 kg for the boars fed the higher protein diet to a minimum of 0.66 kg for the boars fed the lower levels of protein. Barrows and gilts fed the 18% protein diet throughout gained 0.73 and 0.75 kg/day, respectively, whereas the lower protein diet barrows gained 0.72 and gilts 0.69 kg/day to market weight. Bowland and Berg (1959) and Young et al. (1968) observed no first order interactions between sex (barrows and gilts) and protein levels with regard to growth rate. However, these former studies did not include boars and this is the sex in which the major response to higher protein occurred in the present study.

### Feed Conversion (Table 7)

Feed conversion was influenced ($P < 0.05$) by sex for the overall experiment and by dietary protein level for both the 50-90 kg and overall periods. There was no interaction between sex and protein. Boars were superior to gilts and barrows, with feed conversions averaging 3.01, 3.31 and 3.40 kg of feed per kg gain, respectively. Blair and English (1965) reported the entire males utilized feed more efficiently than castrates. Walstra and Kroeske (1968) cited references from different countries in which the boars equalled or surpassed the feed efficiency of barrows. Pigs fed the higher protein diet throughout the experiment had an average of 3.16 kg of feed per kg gain compared with 3.36 kg of feed per kg gain for those pigs fed the lower protein diets.

The overall growth data (Table 7) demonstrate that boars fed an 18% protein diet ad libitum gained as rapidly and more efficiently than barrows and to a lesser extent more efficiently than gilts. A system of restricted feedings would undoubtedly alter some of these comparative results as it would tend to restrict barrows and gilts more than boars. Therefore, boars would have a greater advantage in rate of gain than was shown in this experiment. Walstra (1969) reported that boars will grow faster than barrows when fed restricted diets and barrows will grow faster than boars when fed at libitum.

### Carcass Measurements (Table 8)

Dressing percentage was influenced by both sex and dietary protein level. Boars dressed 75.9%, which was lower ($P < 0.01$) than gilts at 79.3%, or barrows at 79.6%. The differential of 3.7% in dressing percentage between boars and barrows obtained in this experiment places the boars at some economic disadvantage when payment is made on carcass weight. Pigs fed the lower protein ration had an average dressing percentage of 79.0%, which was higher ($P < 0.05$) than 77.5%

TABLE 8. Means of carcass performance for boars, gilts and barrows fed two levels of protein.

| Sex | Boars | Gilts | Barrows | | |
|---|---|---|---|---|---|
| Dietary Protein % | | | | 18 | 16-13 |
| No. animals | 16 | 16 | 16 | 24 | 24 |
| Dressing, % | 75.9 a | 79.3 b | 79.6 b | 77.5 | 79.0* |
| Grade index | 102.6 a | 101.4 a | 97.9 b | 100.7 | 100.4 |
| Total fat[1], cm | 9.62a | 10.79b | 12.14c | 10.74 | 10.97 |
| Area of loin eye, sq cm | 27.0 a | 29.4 b | 25.8 a | 27.4 | 27.3 |
| Area of total ham, sq cm | 211.6 a | 239.8 b | 242.4 b | 228.3 | 234.1 |
| Lean in ham face, % | 54.3 a | 50.2 b | 46.1 c | 51.0 | 49.4 |
| Length of side, cm | 78.1 | 78.7 | 77.0 | 78.1 | 77.7 |
| ROP[2] index | 68.4 a | 67.1 b | 64.5 c | 66.8 | 66.5 |

* Significantly different at $P < 0.05$.

a,b,c Sex means with the same letters or no letters are not significantly different ($P < 0.01$).

[1] Sum of three measurements (shoulder, loin and back).

[2] Record of performance.

for those fed the 18% protein ration.

Boars had a grade index of 102.6 and gilts an index of 101.4, which were higher ($P < 0.01$) than the barrow index of 97.9. Boars had lower ($P < 0.01$) backfat (based on the measurements) than gilts, which in turn were lower than barrows. The results of this experiment agree with reports by Teague et al. (1964) and Martin (1969) indicating that boars produce leaner carcasses than castrates, using less feed in the process.

Gilts were superior to boars or barrows in loin eye area. This is an agreement with Wong et al. (1968), who found that gilts exceeded both boars and barrows in loin eye area. Area of total ham was higher ($P < 0.01$) in barrows and gilts, but the area of lean as a percentage of the ham was greater in boars. This suggests that the greater area of total ham in the barrows is because the hams have more fat. A general trend in carcass length was shown but no statistical differences were found (Table 8). Boar carcasses were similar in length to gilt carcasses but longer than barrows. Teague et al. (1964) reported that barrow carcasses were shorter than those from boars. Associated with their better individual carcass measurements, boars had a higher ROP index of 68.4 than gilts at 67.1, which in turn were superior to barrows at 64.5.

Protein level in the diet did not influence grade index, Canadian ROP index, or any carcass measurements except dressing percentage.

### Carcass, Muscle and Fat Composition

Sixteen of the 24 carcasses were completely dissected into individual muscles, fat, and bone. Boar carcasses had more muscle and less fat ($P < 0.01$) than barrows, with gilts intermediate (Table 9). Protein level did not significantly influence these measurements, although carcasses from pigs fed an 18% protein diet had 2.4% more muscle than those from pigs fed 16-13% protein diets. Total bone appeared to be lower in barrow carcasses than in those of boars or gilts, but no

TABLE 9. Means for total muscle, fat and bone in the carcasses of boars, gilts and barrows fed two levels of protein.

| Sex | Boars | Gilts | Barrows | | |
|---|---|---|---|---|---|
| Dietary Protein % | | | | 18 | 16-13 |
| No. animals | 8 | 4 | 4 | 8 | 8 |
| Muscle, % | 55.9a | 54.3ab | 49.7b | 54.5 | 52.1 |
| Fat, % | 33.9a | 35.6ab | 41.4b | 35.7 | 38.3 |
| Bone, % | 10.2 | 10.1 | 8.9 | 9.8 | 9.6 |

a,b Sex means with the same letters or no letters are not significantly different ($P < 0.01$).

statistical differences were found. The bone to muscle ratio was relatively constant at between 1:5.4 and 1:5.6.

Six muscles were analyzed for dry matter, protein, fat, and ash (Table 10). No significant differences between sex or dietary treatment were found except in percentage of protein in the longissimus dorsi, where pigs fed the higher protein diet had a higher percentage of protein ($P < 0.05$). All other muscles showed a similar trend, but differences were non-significant. There was also a nonsignificantly higher dry matter content in all six muscles from pigs fed the lower protein rations. There were no significant sex X diet interactions associated with carcass measurements and composition.

In the fatty acid analyses of backfat (Table 11), no differences were found except in the percentages of linoleic and linolenic acids. Boars and gilts had higher percentages (9.9, 1.2%; and 9.4 and 0.9%, respectively) of these fatty acids than barrows (7.9 and 0.7%). Field (1971) reported that fat from heavy boars, which contains more unsaturated acids, is softer than fat from barrows. Nine of the 16 boar carcasses from this study showed detectable sexual odor when cooking tests were conducted in the Department of Food Science at the University of Alberta (Tucker, 1971). No sexual odor was observed in meat from the other carcasses.

Boar carcasses are rejected by markets in some countries because of the possibility of odors or flavors inherent in the meat or fat of entire male animals. In Canada, boars cannot be marketed through federally inspected packing plants, although ridglings (cryptorchids) are accepted in regular market channels. Such carcasses are separated by being identified on the rail and subjected to an aroma test to determine their suitability for regular retail outlets. Based on performance criteria, it is possible that if management and marketing procedures could be arranged to handle boars and boar carcasses to overcome the problem of sexual

TABLE 10. Means (%) for dry matter, protein[1], fat and ash from six muscles of boars, gilts and barrows fed two levels of protein.

| Sex | Boars | Gilts | Barrows | | |
|---|---|---|---|---|---|
| Dietary Protein % | | | | 18 | 16-13 |
| No. animals | 16 | 4 | 4 | 12 | 12 |
| Semitendinosus | | | | | |
| Dry matter | 24.8 | 25.0 | 24.9 | 24.5 | 25.3 |
| Protein | 77.7 | 79.0 | 78.4 | 79.4 | 77.3 |
| Fat | 18.0 | 16.6 | 17.5 | 16.5 | 18.3 |
| Ash | 4.3 | 4.4 | 4.1 | 4.1 | 4.4 |
| Gracilis | | | | | |
| Dry matter | 23.4 | 24.8 | 23.8 | 23.8 | 24.2 |
| Protein | 85.6 | 84.6 | 83.7 | 84.7 | 84.5 |
| Fat | 9.9 | 11.0 | 12.0 | 10.9 | 11.1 |
| Ash | 4.5 | 4.4 | 4.3 | 4.4 | 4.4 |
| Longissimus dorsi | | | | | |
| Dry matter | 27.2 | 27.4 | 27.3 | 26.9 | 27.7 |
| Protein | 76.4 | 77.2 | 78.8 | 79.5 | 75.3* |
| Fat | 19.7 | 19.0 | 17.4 | 16.6 | 20.9 |
| Ash | 3.9 | 3.8 | 3.8 | 3.9 | 3.8 |
| Obliquus adbominis internus | | | | | |
| Dry matter | 23.6 | 23.9 | 25.7 | 23.9 | 24.9 |
| Protein | 84.4 | 85.5 | 82.1 | 84.1 | 83.9 |
| Fat | 11.3 | 10.1 | 13.8 | 11.7 | 11.8 |
| Ash | 4.3 | 4.4 | 4.1 | 4.2 | 4.3 |
| Extensor carpi radialis | | | | | |
| Dry matter | 21.5 | 23.6 | 22.1 | 21.9 | 22.9 |
| Protein | 87.3 | 87.1 | 87.1 | 87.5 | 86.7 |
| Fat | 8.2 | 8.4 | 8.4 | 8.0 | 8.7 |
| Ash | 4.5 | 4.5 | 4.5 | 4.5 | 4.6 |
| Rhomboides | | | | | |
| Dry matter | 26.4 | 27.1 | 26.3 | 26.2 | 27.0 |
| Protein | 71.8 | 71.5 | 71.1 | 72.3 | 70.6 |
| Fat | 24.4 | 24.8 | 25.2 | 24.0 | 25.6 |
| Ash | 3.8 | 3.7 | 3.7 | 3.7 | 3.8 |

* Significantly different at $P < 0.05$.

[1] Protein, fat and ash reported on a dry matter basis.

TABLE 11. Weight percent fatty acid composition of the backfat of boars, gilts and barrows fed two levels of protein.

| Sex | Boars | Gilts | Barrows | | |
|---|---|---|---|---|---|
| Dietary Protein % | | | | 18 | 16-13 |
| No. animals | 16 | 16 | 16 | 24 | 24 |
| Fatty acids | | | | | |
| Total Unsaturated | 61.6 | 61.6 | 60.7 | 61.0 | 61.5 |
| Total Saturated | 38.4 | 38.4 | 39.3 | 39.0 | 38.5 |
| C 14:0 | 1.4 | 1.5 | 1.6 | 1.5 | 1.5 |
| C 16:0 | 25.0 | 25.2 | 25.9 | 25.5 | 25.3 |
| C 16:1 | 4.3 | 4.3 | 4.5 | 4.3 | 4.4 |
| C 18:0 | 12.0 | 11.7 | 11.8 | 12.0 | 11.7 |
| C 18:1 | 46.2 | 47.0 | 47.6 | 46.5 | 47.3 |
| C 18:2 | 9.9A | 9.4A | 7.9B | 9.2 | 8.9 |
| C 18:3 | 1.2A | 0.9A | 0.7B | 1.0 | 0.9 |

A, B Means with the same letters or no letters are not significantly different ($P < 0.05$).

odor there might be an economic advantage in raising entire males for meat production, rather than castrated males.

The overall results of the present study indicated that boars fed a barley and wheat-based ration containing 18% protein have a superior feed conversion and slightly superior gain to barrows. When lower protein levels of 16% in the growing period and 13% in the finishing period were fed, boars lost some of their advantage relative to barrows. Most measurements of carcass lean indicated that boars were superior to barrows with gilts being intermediate. Fat composition of boars was similar to gilts in percentages of linoleic and linolenic acids. If sex odor was not a problem the production of boars offers definite advantages compared with barrows.

# PART 3*

## A Device and Procedure to Obtain Serial Backfat Biopsy Cores From Pigs

In serial studies of backfat composition or quality in pigs, it is necessary to obtain biopsy samples from animals at intervals prior to slaughter. If only very small quantities of fat are required the needle biopsy method of Hirsch *et al*. (1960) may be used. This method, slightly modified, gives adequate amounts of fat to conduct determinations on fatty acid composition using gas-liquid chromatography (Elliot and Bowland, 1970).

The quantities of fat obtained by the method of Hirsch *et al*. (1960) are inadequate to conduct sensory tests such as the detection of sex odor in pork by the soldering iron method of Jarmoluk *et al*. (1970). In comparing boars with barrows and gilts, it became necessary to devise a method for obtaining backfat biopsy samples, weighing at least 0.5 g, at weekly intervals prior to slaughter. Results of previous attempts indicated that removal of biopsy samples by standard surgery was not feasible because of the time required, the need for general anaesthetization, and the stress imposed on the pig. The following is a description of a coring device that has been manufactured and the procedure followed in obtaining backfat biopsies.

The coring apparatus is a stainless steel cylinder made of 80 mm thick steel, 1.3 cm in diam and 7 cm long (Figure 1). The end of the cylinder used to take the biopsy core is sharpened; the other end is attached to a 0.63-cm (0.25-inch) chuck, which is in turn attached to a speed-regulated (0-2250 rpm) drill (Black & Decker

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* The material in Part 3 of this thesis has been published as a note in the March, 1972, issue of the Canadian Journal of Animal Science.
Newell, J.A. and Bowland, J.P., 1972, A device and procedure to obtain serial backfat biopsy cores from pigs. Can. J. Anim. Sci. 52: 199-201.

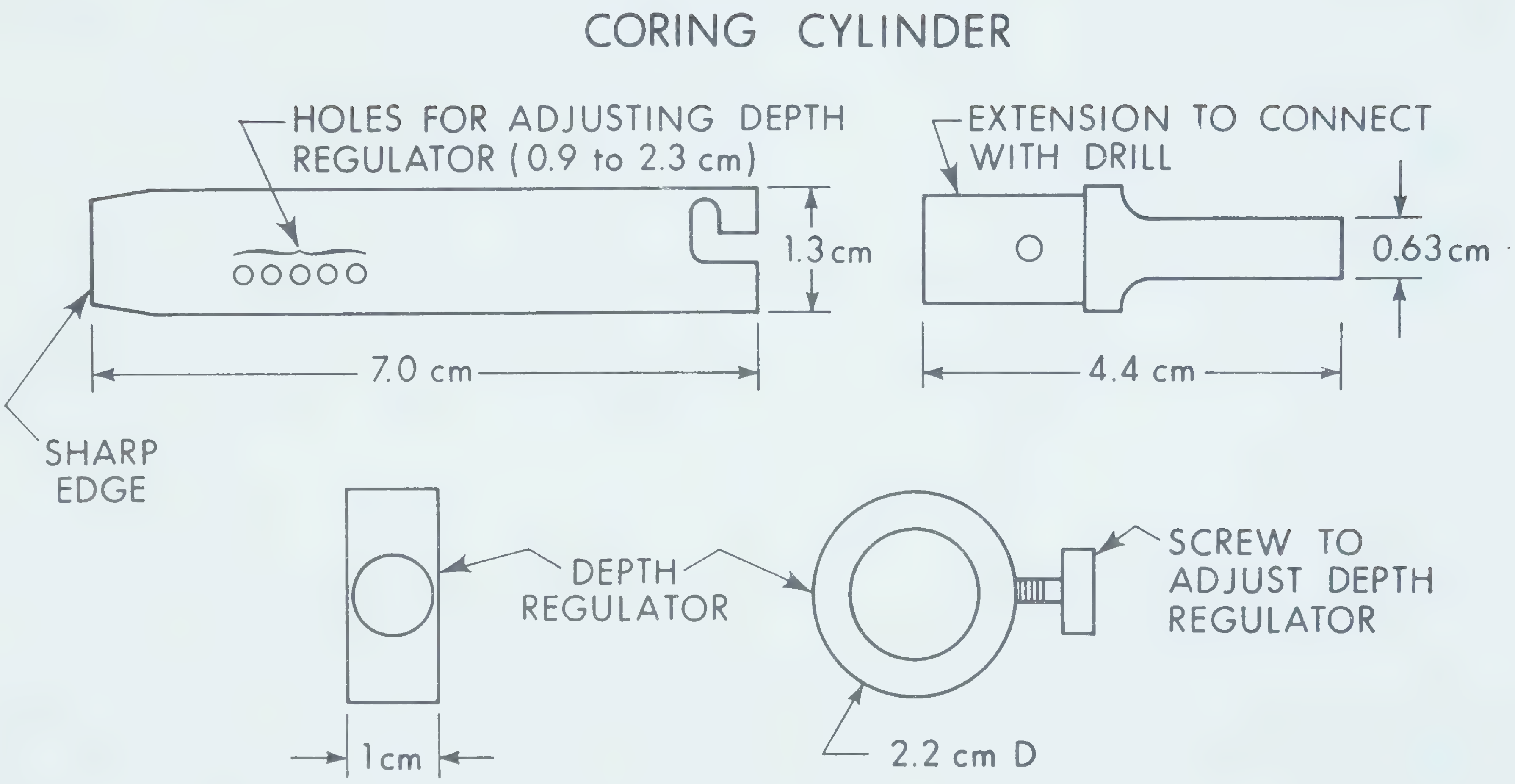

Fig. 1. A coring device to take biopsy backfat samples from pigs.

Variable Speed B-202-5 Deluxe 1/4 inch drill, Black & Decker Mfg. Co., Ltd., Brockville, Ontario). A metal ring with an adjustment screw is attached to the cylinder to regulate depth. The cylinder has several regulating positions so that the depth-regulating screw may be set at between 1.3 and 2.7 cm to prevent the coring device from entering the muscle. This adjustment allows samples to be taken to a depth of approximately 0.9-2.3 cm. The depth regulator may be adjusted according to the weight of the pig and the expected depth of backfat.

One hour prior to taking backfat biopsy cores, the animal was injected intramuscularly with 1 ml of tranquilizer (Anatran (Injectable) No. 2230 (Ayerst Laboratories, Division of Ayerst, McKenna and Harrison Ltd., Montreal)). This tranquilizer contains 25 mg acepromazine maleate per ml. After the tranquilizer became effective the animals were restrained in a press gate. One ml of a local anaesthetic, Novocain brand of procaine hydrochloride (Winthrop Laboratories, division of Sterling Drug Ltd., Aurora, Ontario) was injected subcutaneously around the area of operation. Within 2-3 min, the cores of backfat could be taken (Figure 2). Samples were taken from both sides of the animal in the shoulder area 2-4 cm from the midline in each operation. The cylindrical coring device attached to the drill made a clean cut through the skin into the fat and the biopsy plug tended to protrude from the back. A scalpel was used to separate the fat plug from the lower fat layer adjacent to the muscle layer, allowing easy removal of the core (Figure 3).

To the present, biopsy fat samples have been taken from 28 animals: 20 boars, 4 barrows, and 4 gilts. Biopsies were taken from the boars at approximately 70, 78, and 84 kg liveweight; from the gilts and barrows, at 70 kg liveweight. The depth-regulator screw was set at approximately 2 cm for all samples taken in this study. A total of 136 biopsy samples, weighing approximately 0.8 g each, have been taken. One core from each animal has been used for an olfactory test

Figure 2: The drill and coring device being used to take a backfat sample from a pig restrained in a press gate.

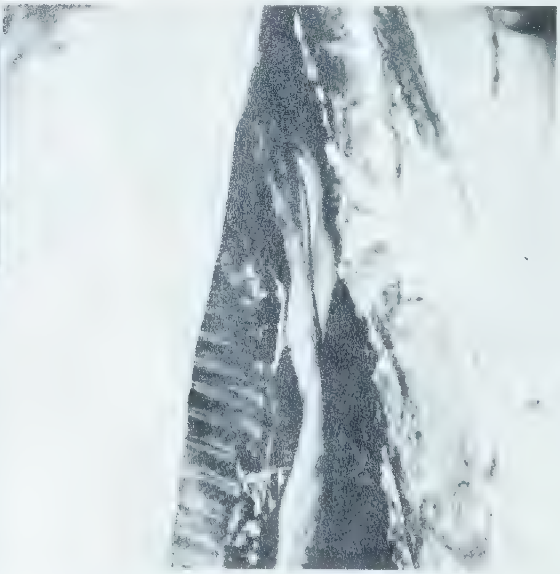

Figure 3: Removal of a biopsy core from the back of a pig. The photograph illustrates the ease of separating the fat core from the lower fat layer.

Figure 4: The operation sites where biopsy cores were removed from the carcass of a 90 kg pig. The cores on each side from front to back of the carcass were removed 3, 2, and 1 week prior to slaughter, respectively.

using the method of Jarmoluk *et al*. (1970). The second core from each animal has been retained for other tests.

After removal of the backfat biopsy core, potassium permanganate was poured on the wound as a disinfectant. There was no evidence of either infection or an adverse effect on performance in any of the animals. The animals were slaughtered at 90 kg and carcasses showed excellent healing at the operation sites (Figure 4).

The device and procedure as described appear to provide a very useful tool for obtaining serial biopsy samples of backfat from pigs prior to slaughter. Further studies are being conducted on the use of the coring device with lighter-weight pigs than those used in this study.

# PART 4*

## Late Castration and Diethylstilbestrol Implantation of Boars - Live Performance and Incidence of Boar Taint

### Introduction

Although the entire male pig is more efficient and produces a leaner carcass than the castrate (Martin, 1969; Newell and Bowland, 1972b, Part 2 of this thesis), the occurrence of taint in the fat has prevented exploitation of this otherwise desirable source of pork. It has been reported (Echternkamp _et_ _al_., 1969; Plimpton _et_ _al_., 1967; Plimpton _et_ _al_., 1971) that implantation of diethylstilbestrol (DES) in boars at 70 kg will increase average daily gain (ADG) and feed conversion (FC) and will reduce the incidence and intensity of taint in boar fat as compared with untreated control boars. Other research has reported a decreased amount of taint in pigs castrated at 82 kg and slaughtered at 100 kg (Bratzler _et_ _al_., 1954). Charette (1961) has suggested that late castration of boars allows realization of the desirable boar characteristics while still permitting slaughter in Canada where the entire male is automatically condemned.

The objectives of this study were to compare the performance, sexual odor (boar taint) and androstenone content of the fat of boars treated with DES at 70 kg liveweight, boars castrated at this weight, intact boars, barrows and gilts.

### Materials and Methods

Forty-four boars, eight barrows and eight gilts were allotted in two time replicates, at an average weight of 13.1 kg in groups of four to six treatments

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* The material in Part 4 of this thesis has been submitted for publication in the Canadian Journal of Animal Science, 1972.
Newell, J.A., Tucker, L.H., Stinson, G.C., and Bowland, J.P., 1972, Influence of late castration and diethylstilbestrol implantation on performance of boars and on incidence of boar taint. Can. J. Anim. Sci. (Submitted for publication).

(Table 12). The 16 boars in treatment 1 were implanted with 96 mg DES (8 stimplants of 12 mg each, 4 in the base of each ear) at 70 kg liveweight. Boars in treatment 2 were castrated at 70 kg with an emasculator. To allow drainage, one external stitch in the outer skin was made. Boars in treatment 3 and 6 were left intact (not castrated or implanted). Two groups of four pigs each of barrows (treatment 4) and gilts (treatment 5) were also included in the experiment for comparative purposes. Barrows in treatment 4 were castrated two days after they were placed on the experiment.

All pigs were fed an 18% protein diet (Table 13) throughout the experiment and had free access to feed and water at all times. This level of dietary protein was based on that giving superior performance in a previous study (Newell and Bowland, 1972b). Animals were crossbreds of various combinations of Yorkshire, Hampshire, Landrace and Lacombe breeding and were alloted at random within sex. Boars were housed in pens which were not adjacent to or across the center aisle from pens containing gilts.

Biopsy fat samples (Newell and Bowland, 1972a, Part 3 of this thesis) were obtained from boars in treatments 1, 2 and 3 at 70, 77 and 84 kg liveweight with a final sample taken from the carcass following slaughter. The intact boars in treatment 6 were left as controls to determine if the biopsy procedure had any depressive effects on performance. Biopsy samples were also taken from the eight barrows in treatment 4 and eight gilts in treatment 5 only at 70 kg liveweight and from the carcass following slaughter. Individual pigs were marketed on the week in which they reached 90 kg liveweight, except that the fourth pig in each lot was shipped when the third pig reached 90 kg.

Biopsy fat samples were used to evaluate the degree of taint as judged by a sensory panel. The samples collected from the carcasses following slaughter were evaluated by two different panels (Table 14). Panel 1 (considered as an untrained

TABLE 12. Allotment of boars, barrows and gilts in castration and diethylstilbestrol (DES) implantation study.

| Treatment No. | No. of pigs[1] | Sex of pigs | Treatment | Wt of sampling (kg) |
|---|---|---|---|---|
| 1 | 16 (4) | Boar | Implanted 96 mg. DES at 70 kg | 70, 77 and 84 |
| 2 | 16 (4) | Boar | Castrated at 70 kg | 70, 77 and 84 |
| 3 | 8 (2) | Boar | Left intact | 70, 77 and 84 |
| 4 | 8 (2) | Barrow | | 70 |
| 5 | 8 (2) | Gilt | | 70 |
| 6 | 4 (1) | Boar | Left intact | no fat samples taken |

[1] Bracketed figures indicate the number of replicate pens per treatment.

TABLE 13. Formulation[1] and composition of diet.

| Calculated Protein | % | 18 |
|---|---|---|
| Ingredients % | | |
| Barley | | 39.7 |
| Wheat | | 40.0 |
| Soybean meal (44%) | | 15.0 |
| Herring meal (72%) | | 2.0 |
| Ground limestone | | 1.0 |
| Dicalcium phosphate | | 1.5 |
| Iodized salt | | 0.4 |
| Trace mineral mix[2] | | 0.1 |
| Zinc sulphate | | 0.05 |
| Vitamin mix[3] | | 0.15 |
| Vitamins A, D and E[4] | | + |
| Aurofac-10 | | 0.1 |
| Composition (by analysis) | | |
| Digestible energy[5] kcal/kg | | 3290 |
| Crude protein % | | 17.8 |

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[1] The formulation of this diet is the same as the 18% protein diet fed to pigs discussed in Part 2 of this thesis.

[2] The mineral mix supplied the following per 100 kg diet: cobalt carbonate, 229 mg; copper sulfate, 2.4 g; ethylene diamine dihydroidide, 110 mg; ferrous carbonate, 23.3 g; manganous oxide, 4.8 g; zinc oxide, 297 mg; ground limestone, 686 g.

[3] The B-complex vitamin mix supplied the following per 100 kg diet: riboflavin 440 mg; calcium pantothenate, 880 mg; niacin, 1980 mg; choline chloride, 2130 mg; folic acid, 13.2 mg; vitamin $B_{12}$, 990 micrograms.

[4] The following vitamins were supplied per 100 kg diet: vitamin A, 495,000 I.U.; vitamin $D_2$, 50,000 I.U.; vitamin E, 1100 I.U.

[5] Calculated from digestibility studies with boars, barrows and gilts.

TABLE 14. Testing panels and methods of evaluation

| | Panel Members | Method Used | Scoring Used[1] | Degree of Training |
|---|---|---|---|---|
| Panel 1 | 4 (2, 2)[2] | Hot Plate | 0 - 3 | Untrained |
| Panel 2 | 8 (4, 4) | Soldering Iron | 0 - 5 | Trained |

[1] Qualitative scoring as follows:

| Panel 1 | | Panel 2 | |
|---|---|---|---|
| 0 | no taint | 0 | no taint |
| 1 | slight | 1 | very slight, just detectable |
| 2 | moderate | 2 | slight |
| 3 | strong | 3 | moderate |
| | | 4 | strong |
| | | 5 | very strong |

[2] Numbers in brackets are women and men.

panel) which evaluated all samples was composed of four members (two men and two women) that were able to smell the chemical associated with boar taint, $5\alpha$ androst-16-en-3-one (Patterson, 1968a). However, it was not a trained panel in the sense that individuals were not trained to distinguish the chemical involved in boar odor from other odors which may be apparent to some people when carcass fat from other pigs is heated. The "hot plate" method was used with scoring from 0 - 3 as described by Tucker (1971). Panel 2 was composed of 6 to 10 (average of 8) men and women who had been selected for their ability to smell androstenone, and had been trained to identify and rate the intensity of boar taint in pork fat. Fat samples identified only by a code number, were scored from 0 - 5 using the hot soldering iron method (Jarmoluk et al., 1970; Patterson and Stinson, 1971).

The androstenone content of kidney fat was quantitatively determined by GLC (Patterson, 1968a) using a 5 cm glass column packed with 1% OV17 on Chromosorb G. Androstenone used as chromatographic and olfactory standards was obtained from three sources: by chromic acid oxidation of androstenol (Bowden et al., 1946), from Sigma Chemical Co., St. Louis, Missouri, and from RLS Patterson, MRI, England (complimentary sample). All three samples had identical chromatographic properties.

The data were analyzed using analysis of variance. There were pen duplicates within time in treatments 1 and 2, but not in treatments 3, 4 and 5. Preliminary analyses of variance made for all traits for treatments 1 and 2 indicated no significant pen differences. Therefore, for final analyses pen differences were not considered. Because of the different pen numbers per treatment combination the analyses of variance of unweighted means as outlined by Bancroft (1968) was used. Individual observations were used in the analysis of average daily gain from initial to market weight. Pen means were used for the analysis of ADF and FC for both periods and ADG for the period from 70 kg to market, treatments ($r = 5$) were

considered as a fixed variable and replication (time, $r = 2$) as random. Those variables which showed significant treatment effects were analyzed using Duncan's multiple range test (Steel and Torrie, 1960). Correlation analyses were done: 1. between degree of taint and weights, 2. for taint measurements between panels, and 3. between degree of taint as determined by olfactory analysis and that obtained by GLC analysis.

## Results and Discussion

### Feed Intake, Gain and Feed Conversion

Two periods were considered in comparing the live performance: The overall period from initial (13.1 kg) to market (90 kg) and the period after treatment was imposed (70 kg) to 90 kg.

For the overall period, pigs in treatment 1, 2, 3 and 5 ate ($P < 0.05$) less feed per day than barrows in treatment 4 (Table 15). The implanted boars in treatment 1 ate less ($P < 0.05$), averaging 2.20 kg of feed per day, than the late castrated boars in treatment 2 which averaged 2.38 kg of feed per day. Although late castrated boars reverted to the performance characteristic of barrows from 70 kg to market weight, they were still superior to barrows. For this period, entire boars (treatment 3) ate less ($P < 0.05$) feed per day than pigs in treatment 2 averaging 2.99 and 3.31 kg of feed per day, respectively. Similar results for DES implanted animals were reported by Teague *et al*. (1964), although no significant differences were found.

For the period from 70 kg to market implanted boars had the fastest rate of gain, averaging 1.02 kg/day which was different ($P < 0.05$) to gilts which averaged 0.85 kg/day (Table 15). No statistical differences were found between treatments 3, 4 and 5 for ADG. This agrees with Newell and Bowland (1972b) who reported no statistical differences for ADG between intact boars, barrows and gilts. Teague

TABLE 15. Means for live performance of boars, barrows and gilts in castration and diethylstilbestrol study.

| Treatment | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| | Boars Implanted | Boars Castrated | Boars Intact | Barrows | Gilts |
| Number of Animals | 16 | 16 | 8 | 8 | 8 |
| Initial-Market | | | | | |
| Av daily feed kg | 2.20B | 2.38C | 2.22BC | 2.57A | 2.31BC |
| Av daily gain kg | .79 | .78 | .77 | .78 | .76 |
| Feed per kg gain kg | 2.78B | 3.05AB | 2.88B | 3.29A | 3.04AB |
| 70 kg-Market | | | | | |
| Av daily feed kg | 3.01BC | 3.31AB | 2.99C | 3.54A | 3.17CB |
| Av daily gain kg | 1.02B | .93AB | .90AB | .87AB | .85A |
| Feed per kg gain kg | 2.95B | 3.56AB | 3.32B | 4.07A | 3.73AB |

A,B,C Means with the same letters or no letters are not statistically different at $P < 0.05$ level.

et al. (1964) reported that implantation of boars with 96 mg DES at 70 kg liveweight resulted in a significant increase in growth rate.

For the overall experiment implanted boars (treatment 1) and intact boars (treatment 3) required less ($P < 0.05$) feed per kg gain, than did barrows (treatment 4) with the other two treatments being intermediate (Table 15). The differences in feed conversion between boars and barrows were noted by Turton (1969) and by Wismer-Pedersen (1968) who reported that the greater efficiency of boars amounted to approximately 0.2 kg less feed per kg gain.

No significant depressive performance was observed following the biopsy procedure at 70 kg although there may have been a slight depression in performance. Intact boars which had biopsy fat samples taken at three weights had an average daily gain of 0.95 kg in comparison with 1.03 kg gain by the control animals between 70 and 90 kg liveweight. Feed intake averaged 3.19 and 3.33 kg of feed per day for sampled and control boars, respectively. Control boars required 3.25 kg feed per kg gain and sampled boars averaged 3.36 kg feed per kg gain.

## Evaluation of Taint

Means of olfactory evaluation by both panels are shown in Table 16. Regression analyses were conducted for treatments 1, 2 and 3. For treatment 3, correlation between weights (70, 77, 84 and slaughter) and degree of taint was found to be low ($r = .06$) but positive, suggesting that in the intact boars the detectable amount of taint seems to reach a plateau at 70 kg liveweight or earlier, increasing only slightly thereafter. Staun (1971) reported that chances that sex odor will be present in boars are as frequent at 55 kg as at 100 kg. Negative ($r = -.41$ and $-.48$, respectively) correlations between weight and degree of taint were found for the late castrated or implanted boars in treatments 1 and 2 indicating that as the animals increased in weight the degree of taint decreased. Ahmad and

TABLE 16. Average panel scores from olfactory evaluation of backfat samples obtained by biopsy and from the carcasses after slaughter.

| Treatment | Biopsy samples | | | Carcass samples (90 kg liveweight) | |
|---|---|---|---|---|---|
| | 70 kg[1] | 77 kg[1] | 84 kg[1] | Panel 1 | Panel 2 |
| 1 Boars implanted | --- | 0.38 | 0.29 | 0.29 | 1.09 |
| 2 Boars castrated | 0.70[2] | 0.23 | 0.22 | 0.25 | 0.41 |
| 3 Boars intact | --- | 0.60 | 0.75 | 0.78 | 1.68 |
| 4 Barrows | 0.23 | | | 0.42 | 0.47 |
| 5 Gilts | 0.38 | | | 0.08 | 0.39 |

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[1] Panel 1 only.

[2] All boars were untreated when samples were taken at 70 kg hence an average is given for 40 boars.

Gower (1968) have shown that 5α-androst-16-en-3-one is synthesized in boar testicular tissue, thus, when the testes are removed (treatment 2) synthesis of 5α-androst-16-en-3-one would cease. Bratzler et al. (1954) reported that no boar odor was present in boars castrated at 82 kg and slaughtered 21 to 44 days later at a weight of 100 kg. DES implantation has also been reported (Plimpton et al., 1967; and Teague et al., 1964) to significantly decrease the intensity of taint although the mechanism of action is not known (Gower, 1972).

A high correlation (r = .53) was found between the olfactory evaluation performed by panel 2 (trained panel of 6 to 10 members) on the fat samples obtained from the carcass after slaughter and the quantity of 5α-androst-16-en-3-one as determined by GLC analysis. This observation agrees with Fuch (1971) who also found a high correlation between taint and quantity of androstenone. Although there was a high correlation between the two panels (r = 0.57) the odor scores obtained by panel 1 did not correlate significantly with the quantity of androstenone found in the fat. This was probably due, in part, to the fact that panel 2 was trained to distinguish the odor of androstenone from other odors present in pork fat, while panel 1 was not.

Because the degree of taint did not increase from 70 to 90 kg in intact boars, a correlation was calculated for the olfactory evaluation of biopsy samples obtained at 70 kg and the fat samples obtained from the carcasses after slaughter. The correlation obtained (r = 0.84) suggests that biopsy samples taken at this weight would give a good prediction of the degree of taint to be found in the carcass. By this time, the performance of the individual pig can be determined thus allowing selection of breeding stock, and then any treatment to reduce taint could be done at 70 kg.

# PART 5

## Late Castration and Diethylstilbestrol Implantation of Boars: Nitrogen and Energy Digestibility and Retention, Carcass Measurements and Muscle Analyses

### Introduction

The fact that boars obtain more benefit from higher dietary levels of protein than is obtained by barrows or gilts was established in an earlier study reported in Part 2 of this thesis. It has also been shown that boar carcasses have lower fat and higher lean than barrow carcasses and that boars require less feed per unit of gain than barrows (Rhodes and Patterson, 1971; and Part 2 of this thesis). A higher nitrogen (N) retention can be postulated as being responsible for the better performance of boars as compared with littermate barrows.

Although boar carcasses are leaner, the occurrence of taint associated with boar fat makes it unacceptable in some countries. Diethylstilbestrol (DES) implantation and late castration of boars have been shown to reduce taint with only minimal influence on performance ( Bratzler *et al*., 1954; Charette, 1961; Teague *et al*., 1964; and Part 4 of this thesis).

The objectives of this experiment were to compare: 1. N and energy digestibility, metabolizable energy and N retention between boars, barrows and gilts; 2. carcass measurements, N muscle analyses and tissue residue for DES of boars implanted with DES at 70 kg liveweight, boars castrated at this weight, intact boars, barrows and gilts.

### Materials and Methods

Forty-four boars, eight barrows and eight gilts were allotted in two time replicates, at an average weight of 13.1 kg, in groups of four animals to six treatments (Table 12). These were the same animals as studied in Part 4 of this

thesis. The 16 boars in treatment 1 were implanted with 96 mg DES (8 stimplants of 12 mg each, 4 in the base of each ear) at 70 kg liveweight. Boars in treatment 2 were castrated at 70 kg with an emasculator. To allow drainage, one external stitch in the outer skin was made. Boars in treatment 3 and 6 were left intact (not castrated or implanted). Two groups of four pigs each of barrows (treatment 4) and gilts (treatment 5) were also included in the experiment for comparative purposes. Barrows in treatment 4 were castrated two days after they were placed on the experiment.

All pigs were fed an 18% protein diet (Table 13) throughout the experiment and had free access to feed and water at all times. This level of dietary protein was based on that giving superior performance in a previous study (Part 2 of this thesis). Animals were crossbreds of various combinations of Yorkshire, Hampshire, Landrace and Lacombe breeding and were allotted at random within sex. Boars were housed in pens which were not adjacent to or across the center aisle from pens containing gilts.

Metabolism studies to determine energy and N digestibility, metabolizible energy and N retention were conducted at two different weights (15 and 50 kg). After receiving an 18% protein diet for 8 days, seven boars, three gilts and three barrows were placed in metabolism cages as described by Castell and Bowland (1968). After three days in the metabolism cages to allow the animals to adjust, feces and urine were collected for a 72 hr period. During the adjustment and collection periods each pig was fed 90% of the average feed consumed by this animal in the week prior to the metabolism trial. Water was available at all times.

Urine and feces were collected each morning during the 72 hr metabolism period. After the final collection, feces were throughly mixed, and a 200 g sample was placed in a forced-air oven at 60°C for 72 hr for dry matter determination. The samples were then ground and gross energy and nitrogen were determined.

Urine volume was measured every day and approximately 100 ml for the composite 72 hr sample was stored at 3°C. Nitrogen content was determined in duplicate on 5 ml samples of wet urine. After freeze-drying 200 ml of urine, duplicate gross energy determinations were conducted on 1 g of freeze-dried urine samples. Methods were as described in Part 1 of this thesis.

Longissimus dorsi muscle samples were obtained from all animals after slaughter. This muscle was chosen as it was the only one of six muscles analyzed in a previous study (Part 2) that showed evidence of significant treatment differences. The muscle samples were analyzed for dry matter, protein, fat and ash (AOAC 1965). Grade Valuation indices and Canadian ROP measurements as described by Bowland (1971) were obtained from all the carcasses.

Analyses of variance were used to statistically analyze the data. Because there were pen duplicates within time in treatments 1 and 2 and not in the other treatments an analysis of variance was done for treatments 1 and 2 and for 3, 4 and 5 separately. Since there were no significant pen differences in treatments 1 and 2, pens were pooled for the analysis of carcass performance and longissimus dorsi analysis. The error mean squares (EMS) were derived using the method outlined by Bancroft (1968). Those variables which showed significant treatment effects were analyzed using Duncan's multiple range test (Steel and Torrie, 1960). In analyzing the metabolism data, sex was included as a variable for the comparisons. The analysis of variance of unweighted means was also used in this latter analysis. Sex was analyzed for time (weight), periods (15 and 50 kg) and for the overall performance.

## Results and Discussion

### Digestibility and Retention Studies (Table 17)

These studies were conducted prior to castration or treatment with DES.

TABLE 17. Means for digestible nitrogen (DN), N retention (RN), digestible energy (DE) and metabolizable energy (ME).

| | DN/kg feed g | DN % | RN/kg feed g | RN/N intake % | RN/DN % | DE/kg feed kcal | DE % | ME/kg feed kcal | ME % | ME/DE % |
|---|---|---|---|---|---|---|---|---|---|---|
| <u>At 15 kg:</u> | | | | | | | | | | |
| Boars | 22.7 | 81.3 | 12.3 | 43.9 | 53.8 | 3299 | 83.2 | 3117 | 80.3 | 96.5 |
| Gilts | 22.9 | 82.3 | 12.2 | 43.7 | 53.3 | 3395 | 83.9 | 3274 | 80.9 | 96.5 |
| Barrows | 23.7 | 85.0 | 11.6 | 41.5 | 48.7 | 3312 | 85.8 | 3176 | 82.3 | 95.9 |
| <u>At 50 kg:</u> | | | | | | | | | | |
| Boars | 25.6 | 88.4 | 16.7 | 57.5 | 65.1 | 3288 | 85.6 | 3212 | 83.6 | 97.7 |
| Gilts | 25.9 | 89.3 | 16.6 | 54.5 | 61.1 | 3352 | 87.5 | 3257 | 85.1 | 97.2 |
| Barrows | 25.7 | 88.5 | 13.6 | 46.9 | 53.1 | 3295 | 86.0 | 3200 | 83.6 | 97.2 |
| <u>Overall average:</u> | | | | | | | | | | |
| Boars | 24.2 | 84.9 | 14.5 | 50.7 | 59.4 | 3258 | 84.4 | 3164 | 81.9 | 97.1 |
| Gilts | 24.4 | 85.8 | 14.4 | 49.1 | 57.1 | 3373 | 85.7 | 3265 | 83.0 | 96.9 |
| Barrows | 24.7 | 86.8 | 12.6 | 44.2 | 50.9 | 3303 | 85.9 | 3188 | 82.9 | 96.5 |

Therefore, only intact boars are included in the comparisons.

At 15 kg liveweight, no statistical differences were found for digestibility or retention. Barrows tended to have higher coefficients for DN but lower N retention than either boars or gilts. Barrows averaged 48.7% N retained/DN in comparison with boars which averaged 55.8% and gilts which averaged 53.3 percent. The same trend observed for DN was shown for DE, but barrows were also nonsignificantly superior to boars and gilts in ME/DE coefficients.

At 50 kg liveweight, DN followed the same pattern as it had at 15 kg, but NR seemed to be influenced more by sex than at the lighter weight. Barrows averaged 46.9% NR and boars and gilts averaged 57.5% and 54.5%, respectively, but no statistical differences between sexes were found. By 50 kg liveweight it could be expected that sexual differences in retention, if such existed, would be more evident than at 15 kg when hormonal differences between sexes would not be as evident. ME for barrows, gilts and boars were 97.2 to 97.7%, all of which values are within the normal range for mixed diets of the type fed.

Although no statistical differences were found when data were combined (15 and 50 kg), barrows tended to digest more N but to retain less than boars or gilts. Barrows retained an average of 12.6 g N/kg feed which was lower than boar or gilts who averaged 14.5 and 14.4 g/kg of feed, respectively. These results support, in general, the carcass data obtained from these animals. No apparent differences were found for DE or ME values where the three sexes seemed to be similar.

### Carcass Performance (Table 18)

Barrows had thicker ($P < 0.05$) backfat (based on three measurements) than any of the other sexes. Implanted and intact boars averaged 9.4 and 9.5 cm total backfat, respectively, which was significantly lower ($P < 0.01$) than barrows which averaged 12.0 cm. Teague *et al*. (1964) reported that barrow carcasses were

TABLE 18. Means of carcass performance for implanted, castrated and intact boars, and for barrows and gilts.

| Treatment | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| | Boars Implanted | Boars Castrated | Boars Intact | Barrows | Gilts |
| Number of Animals | 16 | 16 | 8 | 8 | 8 |
| Dressing, % | 78.4 | 78.6 | 78.8 | 79.5 | 79.0 |
| Grade index | 104.1 B | 102.9 B | 104.1 B | 97.6 A | 101.8 B |
| Total fat[1], cm | 9.40B | 9.78B | 9.47B | 11.96A | 10.11B |
| Area of loin eye, sq cm | 32.0 B | 31.4 B | 33.2 B | 27.3 A | 32.5 B |
| Area of total ham, sq cm | 230.8 | 233.7 | 223.7 | 254.1 | 252.4 |
| Lean in ham face, % | 54.9 | 53.3 | 54.8 | 49.3 | 52.9 |
| Length of side, cm | 77.6 | 77.6 | 77.7 | 76.2 | 76.4 |
| ROP[2] index | 70.3 B | 69.5 B | 70.2 B | 65.9 A | 70.2 B |

A, B Treatment means with the same letters or no letters are not significantly different ($P < 0.05$).

[1] Sum of three measurements (shoulder, loin and back).

[2] Record of performance.

fatter than intact boars or boars implanted at 70 kg with either 48 or 96 mg DES. In the present study, late castrates and gilts averaged 9.8 and 10.1 cm total backfat, respectively. As a result of the thicker backfat measurements, barrows had a lower ($P < 0.05$) grade index than the pigs in the other treatments. Late castrated boars reverted to the performance characteristic of barrows but still were superior averaging 102.9 grade index in comparison with 97.6 for barrows. Implanted and intact boars had average grade indexes of 104.1 each and gilts, 101.8.

No statistical differences were found for dressing percentage although barrows and gilts had a higher numerical dressing percentage than boars. These results agree with those reported in Part 2 of this thesis, where a 3.7% and 3.4% higher dressing percentage for barrows and gilts, respectively, was found in comparison with boars. Loin area was influenced by sex as barrows had a smaller ($P < 0.05$) loin area than any of the other treatments. Intact boars and gilts averaged 33.2 and 32.5 $cm^2$, respectively, and were superior to barrows which averaged 27.3 $cm^2$. Similar results were reported by Bidner et al. (1972) who found significantly larger longissimus dorsi muscles in gilts as compared with barrows. Implanted and late castrated boars were intermediate to barrows and intact boars averaging 32.0 and 31.4 $cm^2$, respectively. It has been observed previously (Baker et al., 1967; Bidner et al., 1972) that feeding of DES + MT to gilts and barrows resulted in an increase in the size of the longissimus muscle over that of untreated controls.

Barrows and gilts appeared to have enlarged areas of total ham compared with boars, but no statistical differences were found between sexes. Percentage of lean in the ham face was greater for boars, regardless of treatment, averaging 54.3% in comparison with gilts or barrows which averaged 52.9 and 49.3%, respectively. Late castrated boars tended to have lower lean content than intact boars. Boars had longer carcasses than barrows or gilts with boars averaging 77.7 cm

in comparison with 76.2 and 76.4 for barrows and gilts, respectively. Barrows had lower ($P < 0.05$) ROP index than any of the other treatments. Late castrated boars showed a general trend to revert to the performance characteristics of barrows but still were superior to barrows. The carcass results for intact boars and for barrows and gilts are similar to those obtained in an earlier study reported in Part 2 of this thesis.

### Muscle Analyses (Table 19)

Longissimus dorsi muscle was analyzed for dry matter, protein, fat and ash. No significant differences between treatments were found, but barrows and late castrated boars tended to have a lower percentage of protein and higher percentage of fat in the muscle. Dry matter and ash contents were found to be similar for all treatments. Similar results were reported by Plimpton *et al*. (1971) who reported that implantation did not significantly affect ether extract, moisture or protein content of the longissimus dorsi muscle.

### Diethylstilbestrol Residue (Table 20)

Ears of the implanted animals were collected from the packing plant. After careful removal of the residual stimplants, it was found that on the average a total of 70.1 mg DES was still left in both ears of each animal. The total weight of the DES implanted was 96 mg. Therefore, approximately 25.9 mg DES was released per animal from the time of implantation at 70 kg to market at 90 kg. This represents an average release of 1.3 mg per day. Similar results were observed by Palmer *et al*. (1971) who reported that after 23 to 40 days following 96 mg DES implantation of boars at 70 kg, an average of 1.1 mg DES was released per day from eight 12 mg pellets.

Frozen samples of the longissimus muscle from intact and implanted boars were stored at −20°C until sent for residue analyses to two federal laboratories,

TABLE 19. Means of longissimus dorsi muscle analyses for boars, gilts and barrows.

| Treatment | | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | | Boars Implanted | Boars Castrated | Boars Intact | Barrows | Gilts |
| Number of Animals | | 16 | 16 | 8 | 8 | 8 |
| Dry matter | % | 25.7 | 26.1 | 26.0 | 26.0 | 25.9 |
| Protein[1] | % | 89.0 | 86.2 | 88.2 | 85.1 | 88.7 |
| Fat[1] | % | 6.4 | 9.3 | 7.4 | 10.4 | 6.7 |
| Ash[1] | % | 4.6 | 4.5 | 4.4 | 4.5 | 4.6 |

[1] Dry matter basis.

TABLE 20. Diethylstilbestrol residues in longissimus dorsi muscle of intact boars and boars implanted with 96 mg DES at 70 kg liveweight.

| Sample Identification | DES residue (ppb) Federal Laboratories | |
|---|---|---|
| | Halifax | Toronto |
| Intact Boars | | |
| 158 | not detectable | not detectable |
| 183 | " | " |
| 191 | " | " |
| 202 | " | " |
| 350[1] | | " |
| 360[1] | | " |
| 361[1] | | " |
| Implanted Boars | | |
| 160 | not detectable | not detectable |
| 169 | " | " |
| 175 | " | " |
| 181 | " | " |
| 185 | " | " |
| 201 | " | " |
| 204 | " | " |
| 326[1] | | " |
| 349[1] | | " |
| 351[1] | | " |
| 356[1] | | " |

[1] Samples sent to Toronto only.

(Toronto and Halifax) of the Department of National Health and Welfare. A gas liquid chromatographic method, sensitive to 2 p.p.b., was used to analyze these samples. No detectable residues were found in any of the samples analyzed by either of the two laboratories (Table 20).

# GENERAL DISCUSSION AND SUMMARY

Boars and gilts fed *ad libitum* consumed less ($P < 0.05$) feed than barrows when fed diets containing either 18% protein throughout or 16% protein to 50 kg liveweight and 13% protein from 50 to 90 kg. Sex did not significantly influence rate of gain which averaged 0.71 and 0.74 kg/day in the experiments reported in Part 2 and 4, respectively. Boars were more efficient ($P < 0.05$) in feed and energy conversion than barrows with gilts being intermediate. Higher dietary protein improved performance of boars more than that of barrows with gilts being intermediate in their response to protein. A system of restricted feeding would undoubtedly alter some of these comparative results as it would tend to restrict barrows and gilts more than boars. Therefore, boars would probably have a greater advantage in rate of gain than was shown in this experiment, but they might lose some of their advantage in carcass quality.

Boars had a lower ($P < 0.01$) dressing percentage than gilts or barrows, but complete carcass dissection, carcass measurements associated with lean to fat ratios and Canadian grade index ranked boar carcasses as superior to barrow carcasses. Gilt carcasses were intermediate in some criteria and equal to boar carcasses in others. Protein level in the diet did not significantly alter any carcass measurements except dressing percentage which was higher for pigs fed the lower protein levels. No differences associated with sex were observed in composition of the six muscles (semitendinosus, gracilis, longissimus dorsi, obliquus abdominis internus, extensor carpi radialis, and rhomboides) which were dissected. Higher protein increased ($P < 0.05$) percentage of protein in the longissimus muscle only. Fatty acid analyses of backfat showed no significant differences between sexes except in linoleic and linolenic acid for which boars and gilts had higher ($P < 0.05$) percentages than barrows.

Digestion coefficients for nitrogen (N) and energy averaged 85.8 and 85.3%, respectively, and did not differ among the three sexes, although barrows tended to digest more than boars or gilts. N retained as a percentage of N intake was similar for boars and gilts (50.7 and 49.1%, respectively) but both were non-significantly higher than for barrows which averaged 44.2% N retention.

Implantation with DES had no significant effects on boar performance or on carcass characteristics but it removed evidence of 'boar taint' in the carcass fat. Possible tissue residues of DES were checked in frozen samples of the longissimus muscle from intact and implanted boars. Samples were sent to two federal laboratories (Toronto and Halifax) of the Department of National Health and Welfare. No detectable DES residues were found in any of the samples by either of the two laboratories using a gas-liquid chromatographic method which was sensitive to 2 p.p.b.

Following late castration at 70 kg liveweight, boars reverted to the performance characteristic of barrows but late castrated boars were still superior at market weight to barrows or gilts in efficiency of feed conversion and carcass lean to fat ratios. Late castration also removed evidence of 'boar taint' which was present in different degrees in over 50% of the intact boars on the basis of panel olfactory evaluation test of heated fat. Biopsy cores were taken from boars at weekly intervals starting at 35 kg liveweight using a method and procedure developed for sampling backfat in live pigs. Marked evidence of 'boar taint' based on olfactory evaluation appeared in some boars at 50 kg liveweight.

It can be concluded by the results of the preliminary rat experiment that this species does not perform similarly to pigs in the parameters tested in this experiment. Therefore, as a predictor of performance of pigs of different sexes, laboratory rats are not a satisfactory investigating tool.

The results of our experiments and of experiments conducted elsewhere

indicate that ad libitum fed boars, particularly if they are given a relatively high protein (high essential amino acid) diet from weaning to market have equal or better gain, superior feed conversion and less backfat than contemporary gilts or barrows. Because of their superior efficiency of feed conversion and superior carcass lean to fat ratios in comparison with barrows, boars offer commercial promise as meat animals, particularly if management practices involving late castration or DES implantation can be evolved.

The device and procedure to obtain serial backfat biopsy cores from pigs as described previously appears to be a useful tool if high correlations can be obtained between sensory and chemical evaluations of taint at an early stage of growth and that are present at normal market weight. From the experimental standpoint, this procedure avoids the unnecessary killing of animals at different stages of maturity and furthermore, it has the advantage of testing the same animal throughout the experiment. For example, we have found that sensory evaluation of biopsy fat samples taken at 70 kg liveweight seems to be a good predictor of the degree of taint to be found in the carcass. By 70 kg liveweight, the performance of the individual boar can probably be determined with reasonable accuracy, thus allowing selection of breeding stock. At this weight, any treatment to reduce taint could be done.

It is also probable that the majority of consumers would be unable to detect sexual odor from young boars even though such an odor may be detected by trained panelists. With large swine operations with proper facilities for management, feeding and marketing of boars it should be possible to take advantage of their desirable characteristics and overcome the one major disadvantage, potential 'boar taint'.

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Appendix Table i. Means for performance, not presented in Part 2, for boars, gilts and barrows fed two levels of protein.

| Sex | | Boars | Gilts | Barrows | | |
|---|---|---|---|---|---|---|
| Dietary Protein % | | | | | 18 | 13 |
| No. of animals | | 18 | 18 | 18 | 24 | 24 |
| Age to market[1] | days | 156 | 157 | 157 | 150 | 160 |
| Liveweight | kg | 92.2 | 93.0 | 90.5 | 92.7 | 91.0 |
| Weight of carcass | kg | 70.0 | 73.8 | 71.8 | 71.9 | 71.8 |
| Skin | % | 7.1 | 6.5 | 6.4 | 7.3 | 6.0 |
| Muscle/bone ratio | | 5.5 | 5.4 | 5.6 | 5.6 | 5.5 |
| Weight of ham | kg | 8.2 | 8.6 | 8.2 | 8.2 | 8.3 |
| Area of lean in ham, | sq cm | 114.8 | 120.0 | 111.6 | 115.5 | 114.8 |
| Percentage ham of side | | 26.5 | 26.4 | 26.3 | 26.5 | 26.2 |

[1] Corrected to an average age on test of 41 days and market weight at 90 kg.

Appendix Table ii. Means for performance, not presented in Part 5, for implanted, castrated and intact boars and for barrows and gilts.

| Treatment | | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | | Boars Implanted | Boars Castrated | Boars Intact | Barrows | Gilts |
| Number of Animals | | 16 | 16 | 8 | 8 | 8 |
| Age to market[1] | days | 155 | 156 | 153 | 152 | 154 |
| Liveweight | kg | 93.4 | 91.6 | 91.5 | 91.4 | 90.1 |
| Weight of carcass | kg | 73.3 | 72.0 | 72.1 | 72.8 | 71.2 |
| Weight of ham | kg | 8.9 | 8.4 | 8.4 | 8.2 | 8.6 |
| Area of lean in ham, | sq cm | 126.4 | 123.8 | 122.6 | 125.1 | 132.9 |
| Percentage ham of side | | 26.8 | 26.8 | 27.1 | 25.6 | 27.5 |

[1] Corrected to an average age on test of 55 days and market weight of 90 kg.

Appendix Table iii. Means of metabolism studies at different periods (15 and 50 kg liveweights), not presented in Part 5.

| | DN/kg feed g | DN % | RN/kg feed g | RN % | RN/DN % | DE/kg feed kcal | DE % | ME/kg feed kcal | ME % | ME/DE % |
|---|---|---|---|---|---|---|---|---|---|---|
| Boars[1] | | | | | | | | | | |
| 15 kg | 22.7 | 81.3 | 12.3 | 43.9 | 53.8 | 3229 | 83.2 | 3117 | 80.3 | 96.5 |
| 50 kg | 25.6 | 88.4 | 16.7 | 57.5 | 65.1 | 3288 | 85.6 | 3212 | 83.6 | 97.7 |
| Significance | ** | ** | ** | * | | | * | | ** | ** |
| Gilts and Barrows[2] | | | | | | | | | | |
| 15 kg | 23.3 | 83.6 | 11.9 | 42.6 | 51.0 | 3354 | 84.8 | 3225 | 81.6 | 96.2 |
| 50 kg | 25.8 | 88.9 | 15.1 | 50.7 | 57.1 | 3323 | 86.8 | 3228 | 84.3 | 97.2 |
| Significance | ** | * | ** | ** | ** | | | | | ** |

[1] Seven boars were used in the trial.

[2] Three gilts and 3 barrows were combined.

* Significant at the ($P < 0.05$) level.

** Significant at the ($P < 0.01$) level.